pv magazine spotlight

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Ground-mounted PV system Safety Examined

Jason Bobruk
Director Code Compliance
SolarEdge

Kleber Facchini
Director of Technical Marketing, Commercial & Utility
SolarEdge

Bill Brooks
Principal
Brooks Engineering

15 September 2022

11:00 am – 12:00 pm PDT, Los Angeles
2:00 pm – 3:00 pm EDT, New York City

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Welcome!

pv magazine spotlight

Do you have any questions? ❓ 🙋

Send them in via the Q&A tab. 👉 We aim to answer as many as we can today!

You can also let us know of any tech problems there.

We are recording this webinar today. 📹

We‘ll let you know by email where to find it and the slide deck, so you can re-watch it at your convenience. 👀 💡

Ground-mounted PV system Safety Examined

About the Speakers

Bill Brooks

NEC Expert &
Principal, Brooks Engineering

Kleber Facchini

Director of Technical Marketing,
Commercial & Utility,
SolarEdge North America

Jason Bobruk

Director of Code Compliance,
SolarEdge North America

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Agenda

- The importance of PV safety for ground mounts and carports
- Ground and arc fault discussion
- SEDG system and solution
- S-1200/1 Introduction
- Q&A

Introduction

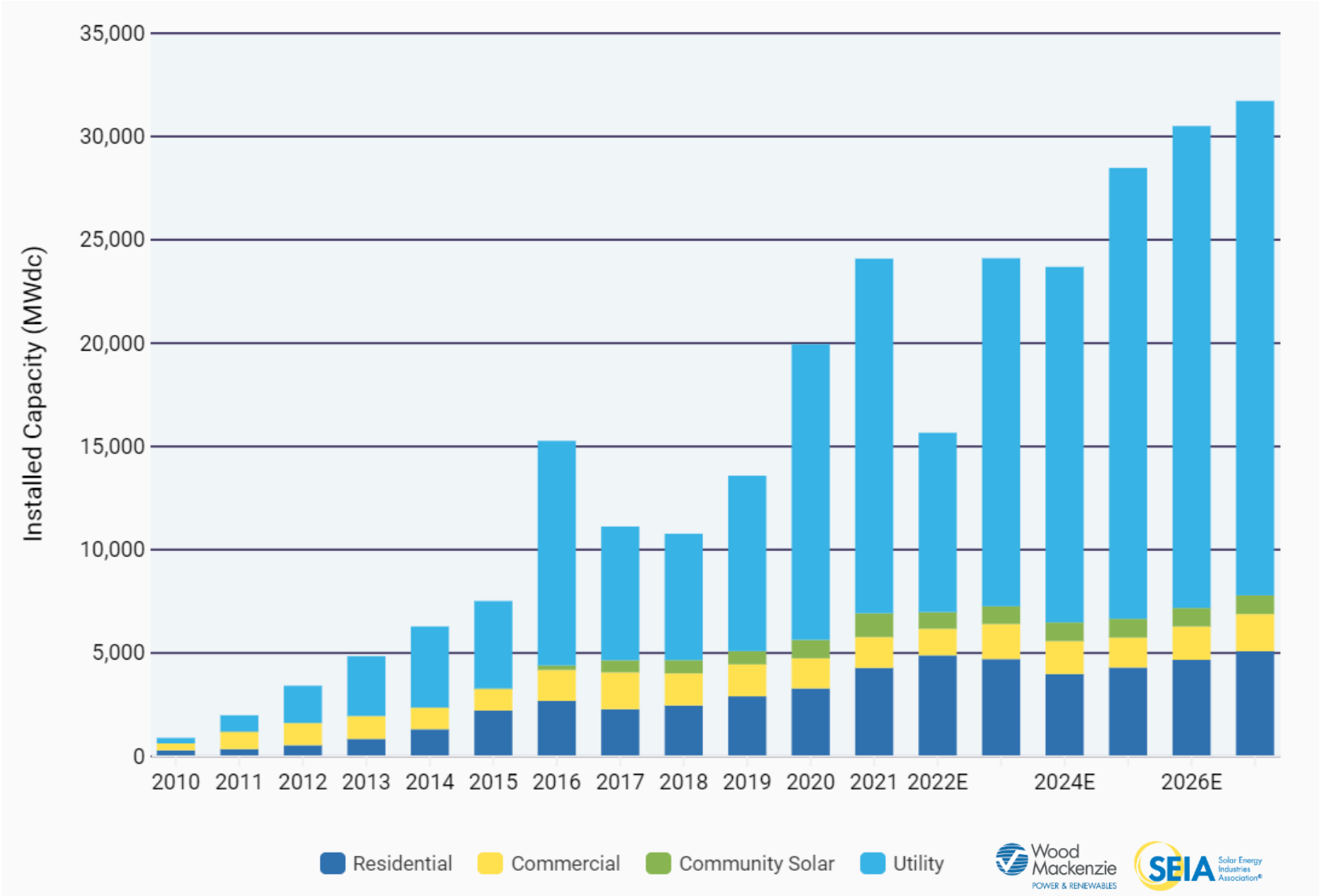
- The rooftop PV industry has evolved to include several safety measures like:
  - Ground fault protection – roof and ground mount systems
  - Arc fault detection – rooftop systems
  - Rapid shutdown – rooftop systems
- Why has ground mount PV lagged in such progress?

Fire Risk is Evolving Due to Change

- Growth of ground mounted DER near dwellings and around people
  - Community solar and energy storage
  - Carports, EV charging
- Climate change increases the frequency of hotter dryer conditions
- Poor vegetation management as projects age

Commercial solar carports | RenEnergy solar canopies

Growth in Commercial and Utility Projects



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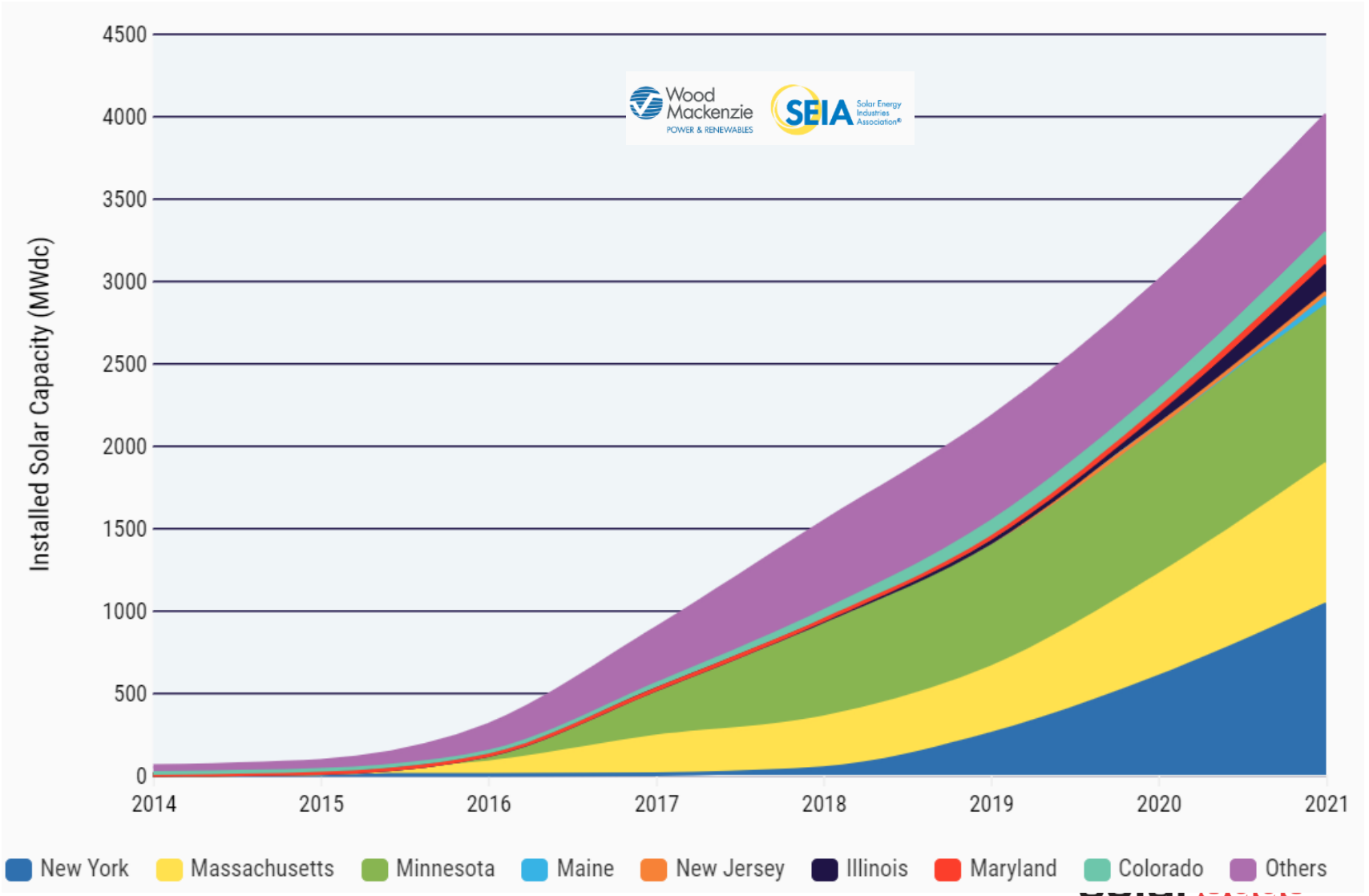
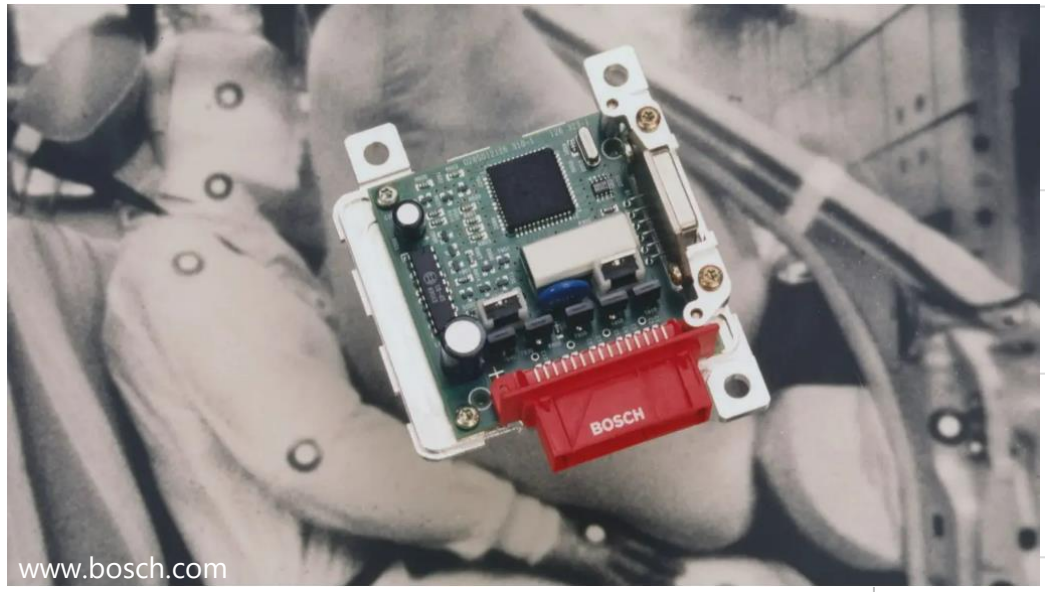
Growth in Community Solar

4.9 GWs of community solar has been installed in the US through Q2 2022

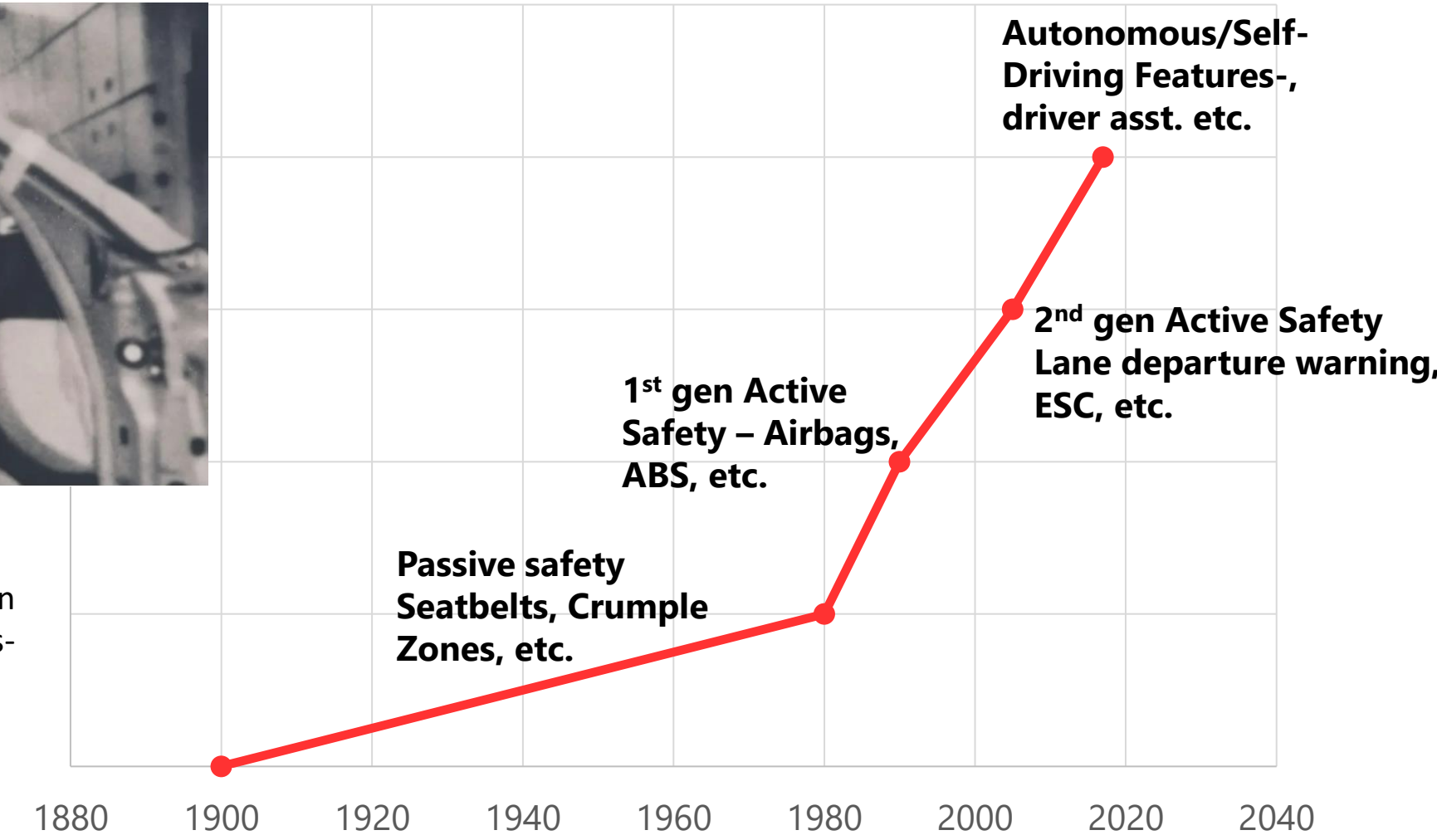
At least 7GW of US community solar is expected to come online in the next five years - Woodmac



Growth in Automotive Safety Technology



Bosch's electronic control unit for passive restraint systems went into series production in 1980 and saw its first use in the Mercedes-Benz S-Class in 1981. It had three ignition outputs to trigger a driver airbag and a two-step passenger airbag or the same number of belt tensioners.



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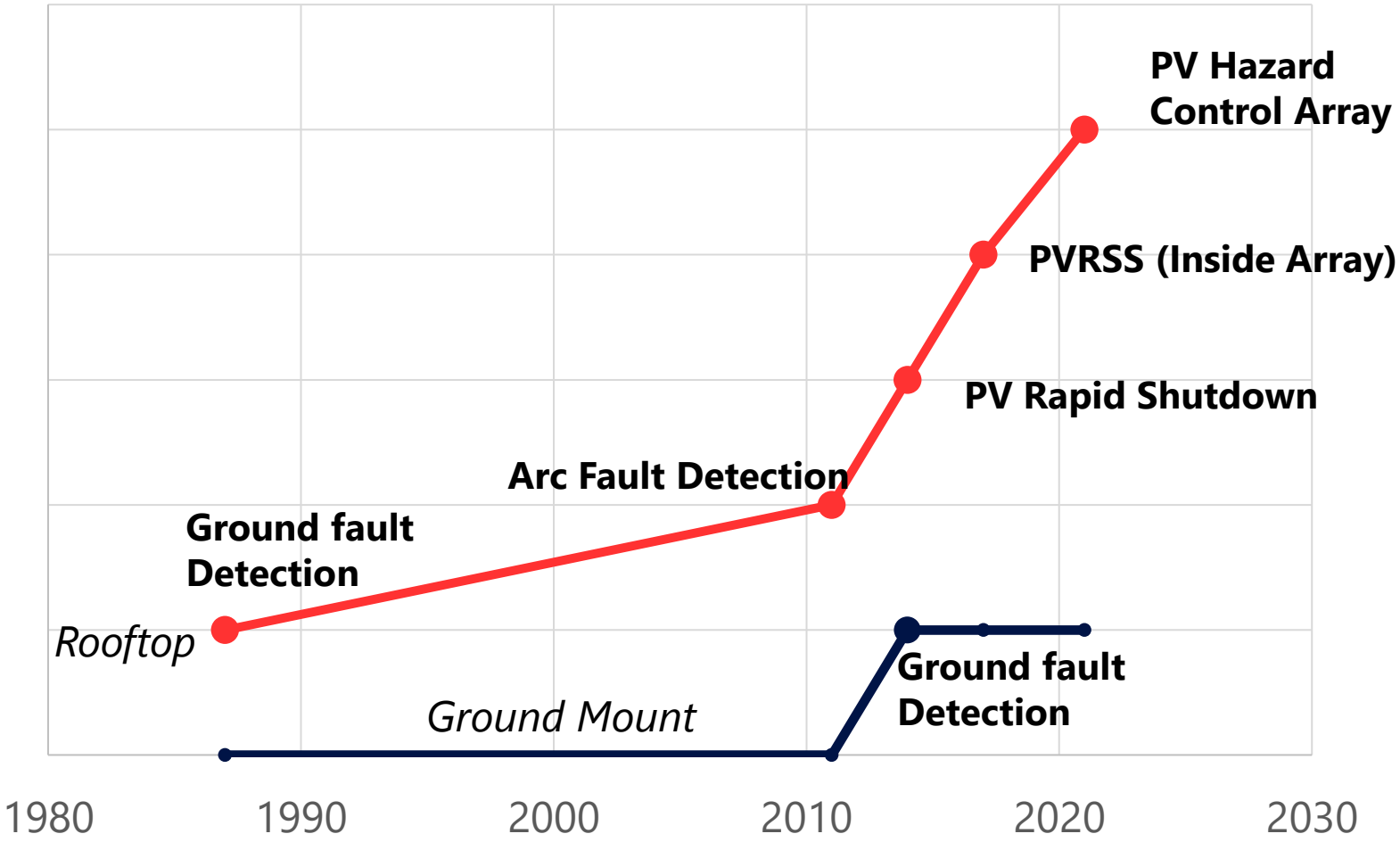
Growth in PV Safety Technology

A first-generation arc-fault circuit breaker. (Photo courtesy of Safran Electrical and Power.)

Early investigations made between 1978 and 1982 by the US navy documented hundreds of wiring incidents, some of which caused aircraft in-flight fires. They were attributed to insulation breakdown due to pyrolysis (aggravated by moisture, temperature, and mechanical stresses),



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Ground Fault Statistics

- A fleet of 85,000 inverters was analyzed for optimizer shutdown due to ground faults
- 31 million days of operation
- Resulted in 13,200 days of de-energized DC wires
- Arrays are safely de-energized about 1 day for every 2400 operational days to avoid potential thermal events

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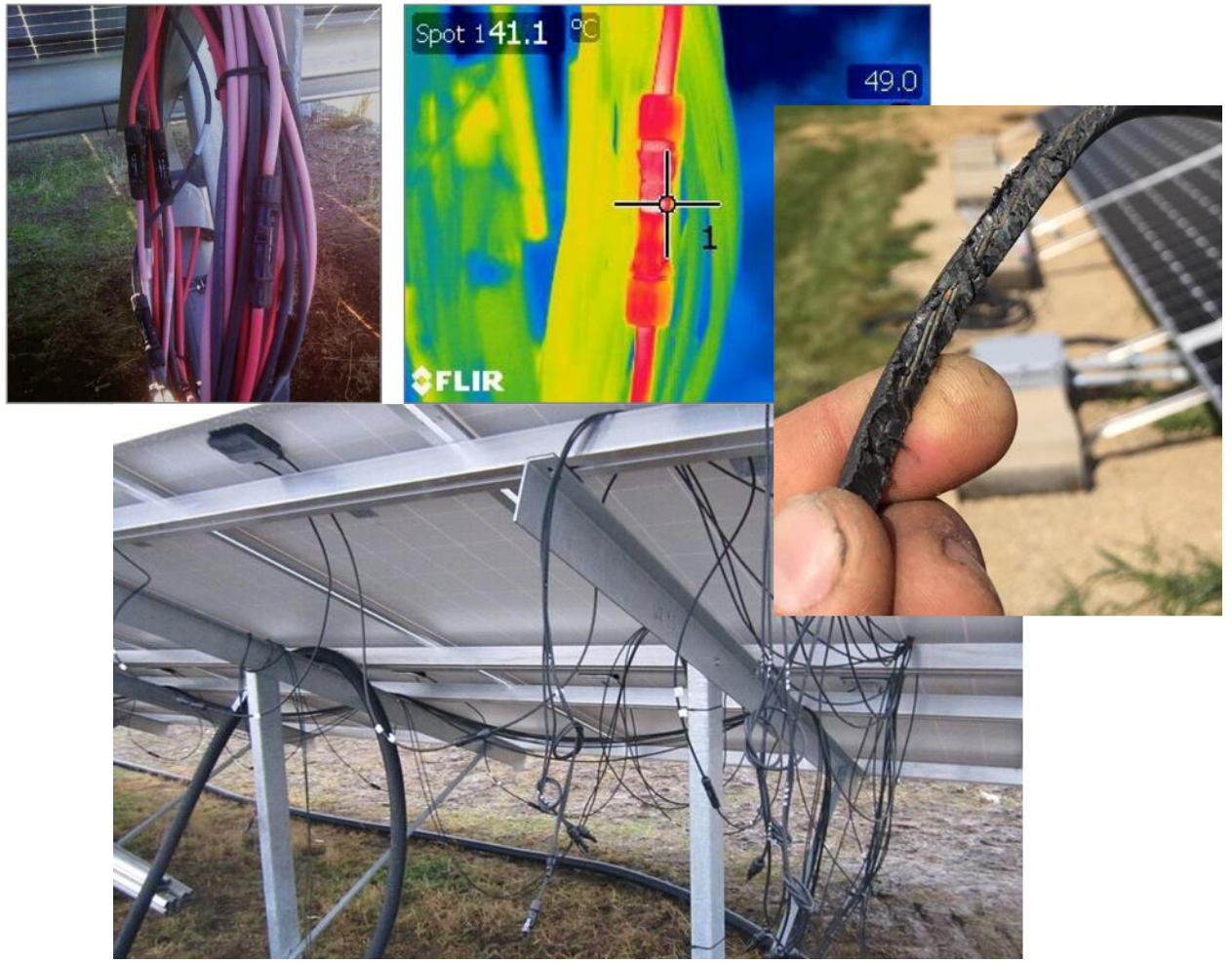
Understanding the Risk

- A properly installed and maintained ground mount PV system has minimal risk
- Faults become more likely as systems naturally age and weather over time
- **Traditional DC arrays remaining energized upon Ground Faults and Arc Faults <u>even when the inverter reacts properly</u>**
- A faulted DC array that is not repaired quickly increases the risk of fire on onsite
- Ground mount arrays often have long intervals between maintenance even when monitored



Solar Cables (vision-media.co.in)

This is why wire management is important folks : solar (reddit.com)

In the News

- *A large asset owner experienced "critical fire or arc flash events" affecting 12.7% of its facilities*
- *"The rate of dangerous incidents is unacceptable and above industry averages"*

Fresno Fire Department

www.cnbc.com/2022/09/01

Testimonials

"Insurance companies are starting to pay (a lot) more attention to safety measures in ground mount systems due to recent events in roof top systems, widespread wildfires and logistical delays on equipment"

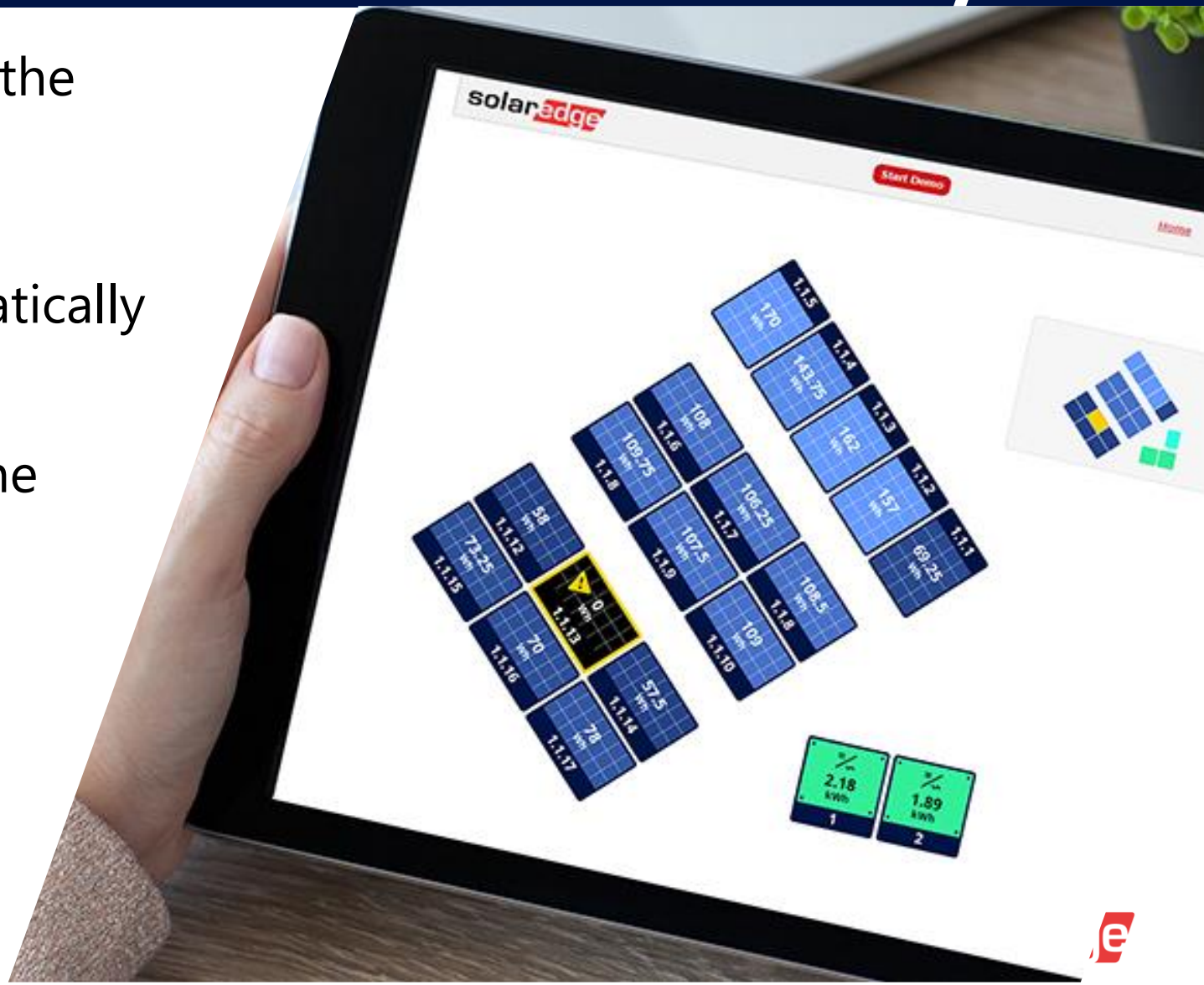
"Wildfire risk has increased everywhere due to climate change"

"Vegetation management by itself is no longer enough to prevent fire events"

-Alan Stearns, Senior Vice President, Lockton Insurance Brokers

Overcoming the Risks

- #1 Accurately and reliably detect the fault
- #2 Take immediate action automatically
- #3 Stop the flow of energy into the fault



Ground Faults and Arc Faults

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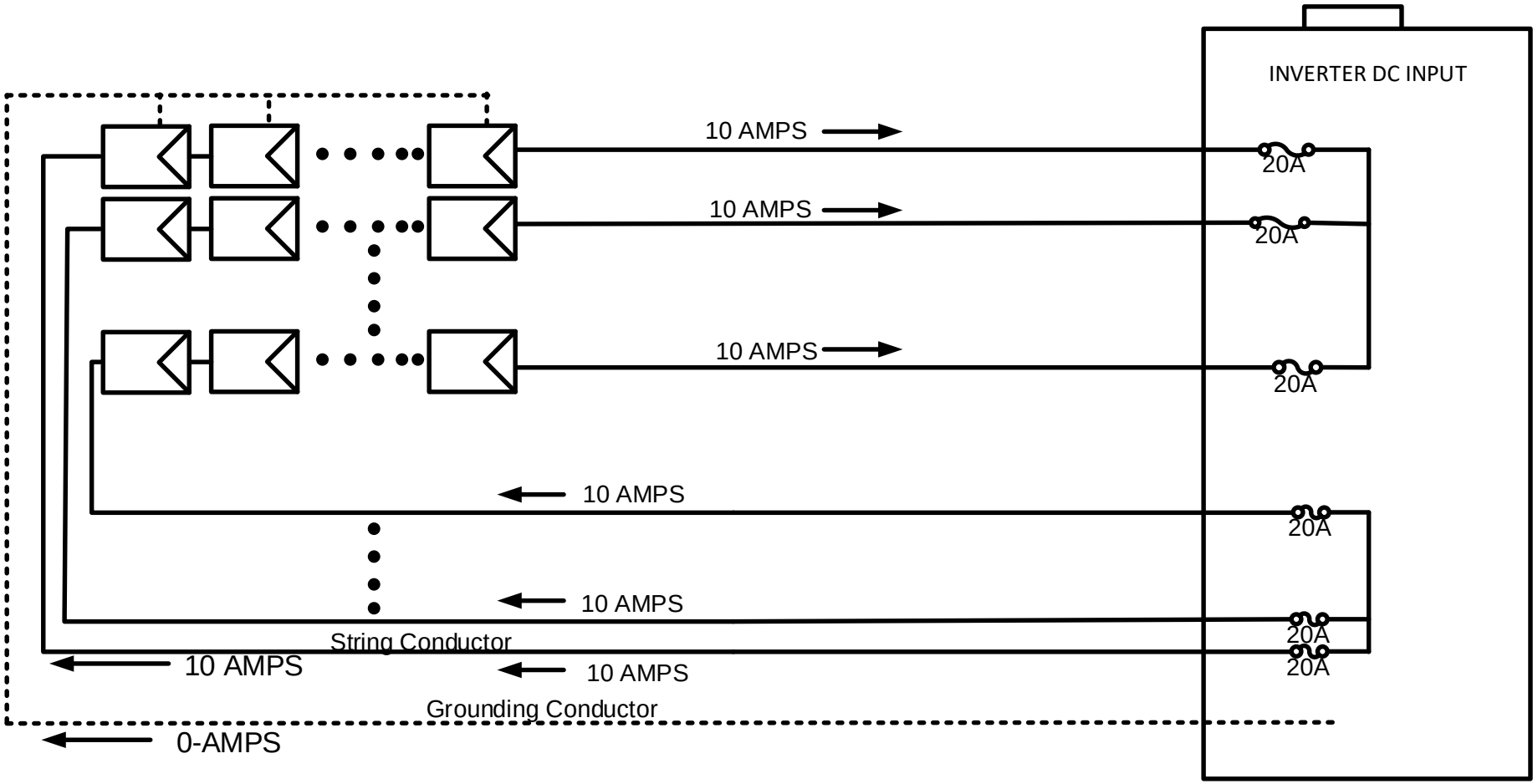
Array Ground Faults

- ***NEC690 does not require circuits to be deenergized after a ground-fault or arc-fault***
- Upon a ground fault, inverter is required to stop production, but the PV panels remain energized.
- Experience shows that once a ground-fault occurs in a PV Array, there is a higher probability that a second array ground-fault will happen if the first fault is not addressed in a timely manner
- A second fault can result into arc faults and increase risk of fires

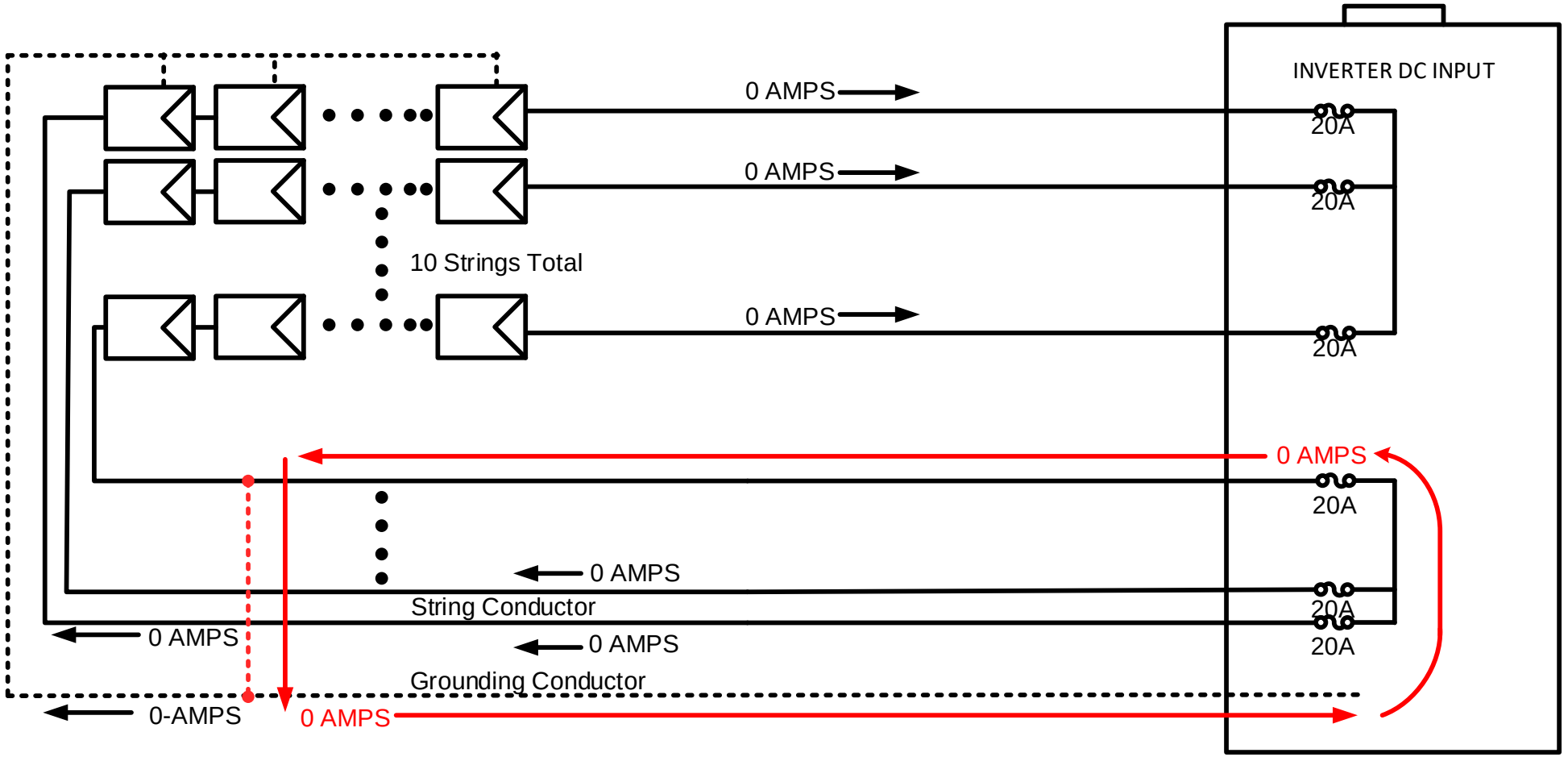
Array Ground Faults

- Ground-faults can occur in any electrical system.
- PV system dc circuits can be particularly problematic



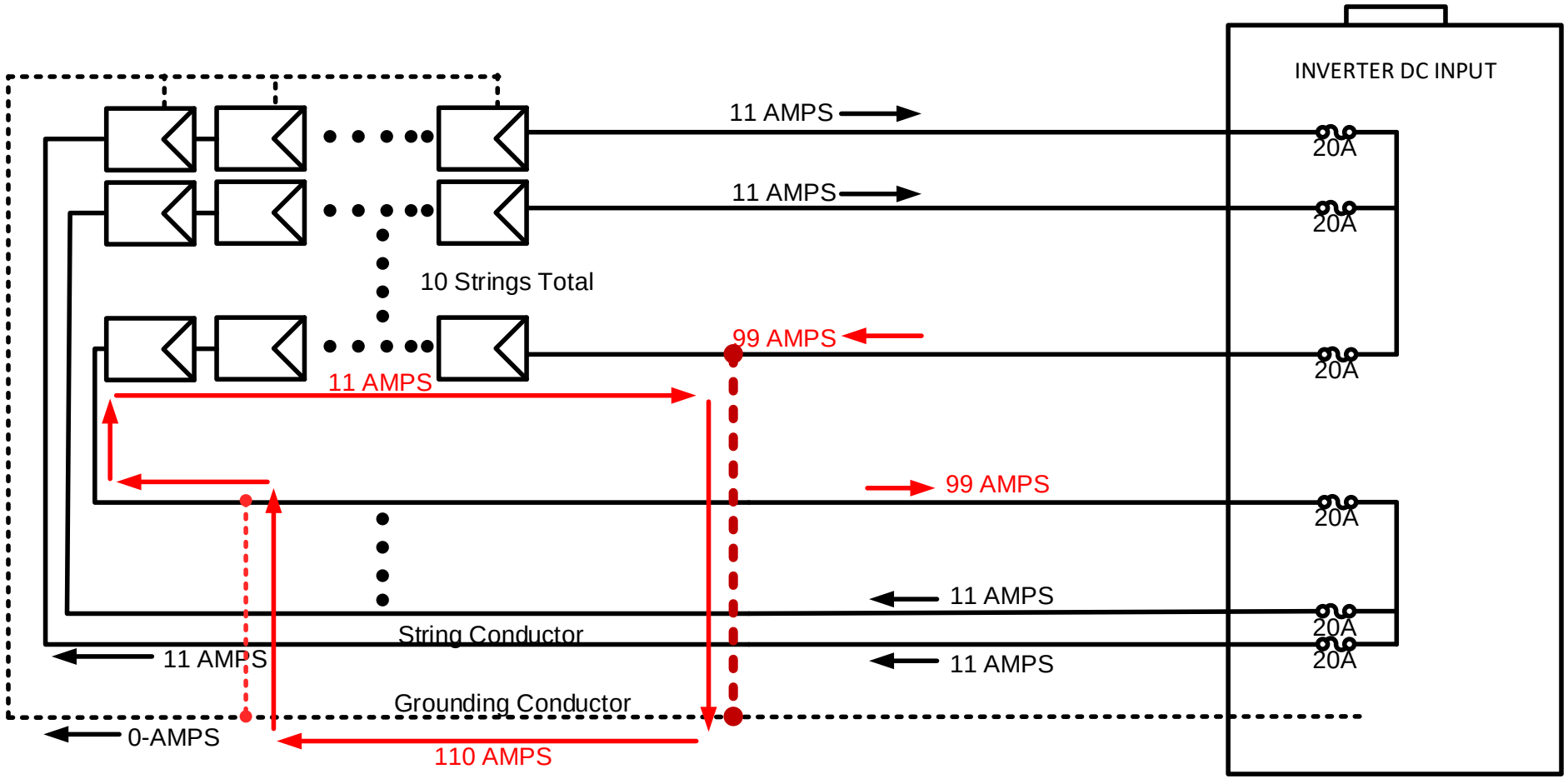
Array Ground Faults

- First fault may not cause current to flow.



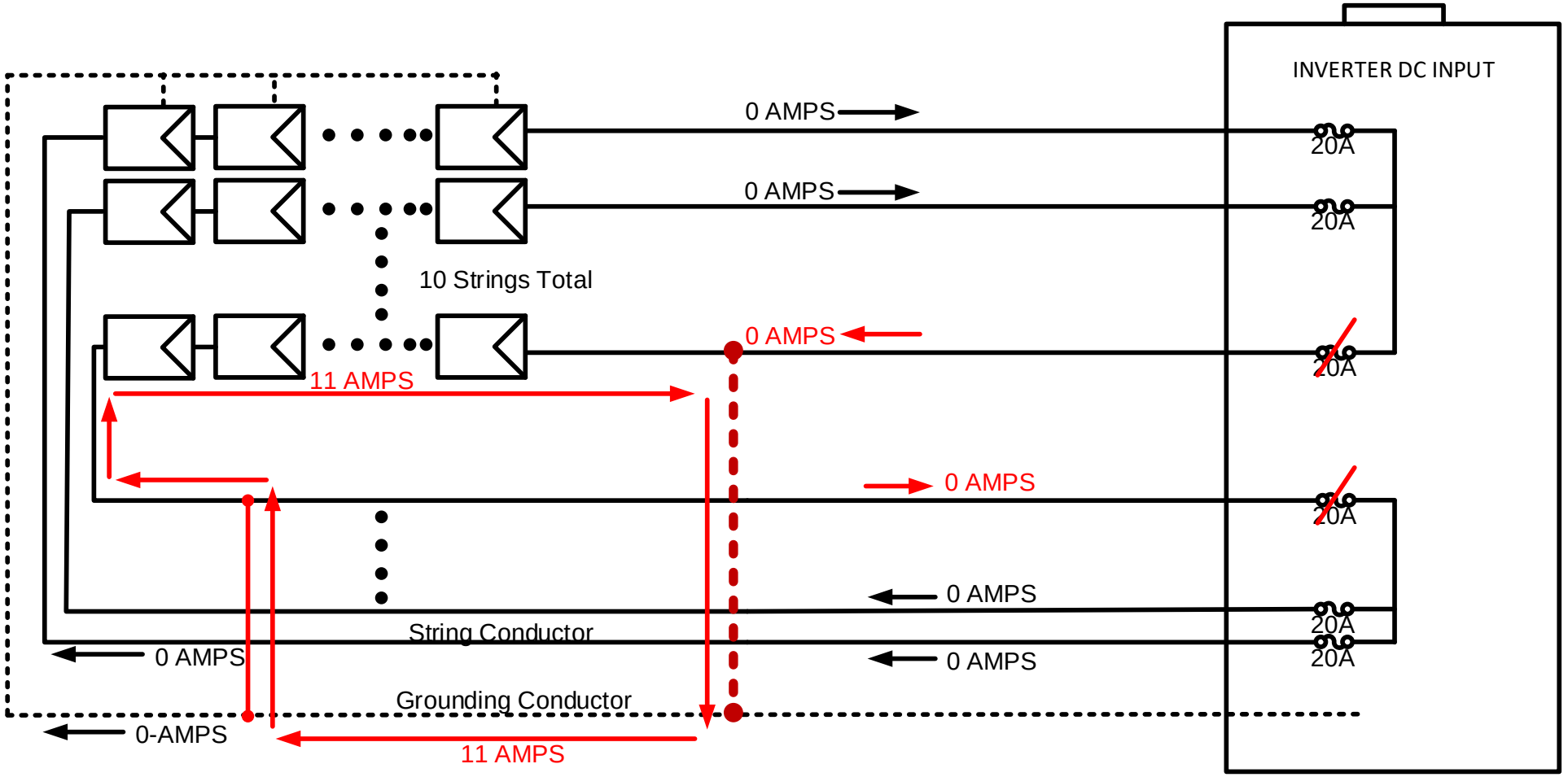
Array Ground Faults

- If second ground-fault is in the same string, other issues arise.
- Large currents flow from the parallel strings.



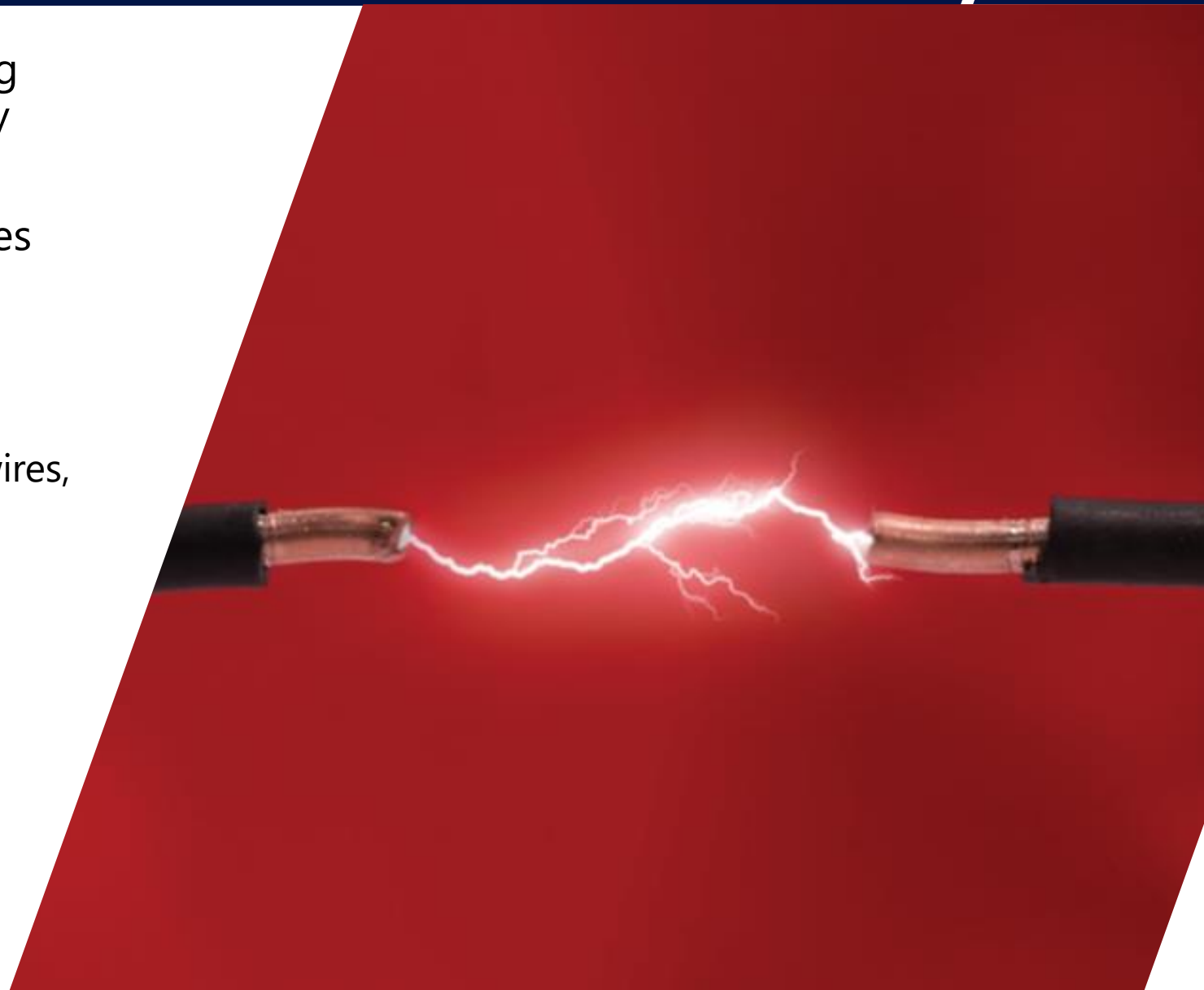
Array Ground Faults

- Current remains after fuses blow often resulting in fire.



Electric Arcs Can Also Pose a Risk

- Ongoing high-energy discharges, resulting from a current passing through a normally non-conductive media such as air
- Creates a shock hazard or potential for fires due to electrification of the installation
- Common causes:
  - Faulty or improperly connected cables or connectors, corrosion, animals chewing wires, failed DC isolators
  - Over-heating of PV system component
  - Arc risk increases with system aging due to degradation of connections and cables



The SolarEdge Solution for Increased Safety

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The basics - SolarEdge Solution with SafeDC™

DC array voltage reduction to safe levels

- SafeDC™ lowers PV system's DC voltage to touch-safe within up to five minutes upon system faults

- Upon a Ground fault or Arc Fault, the array is kept at a safe DC voltage level and string current flow ceases until personnel is on site

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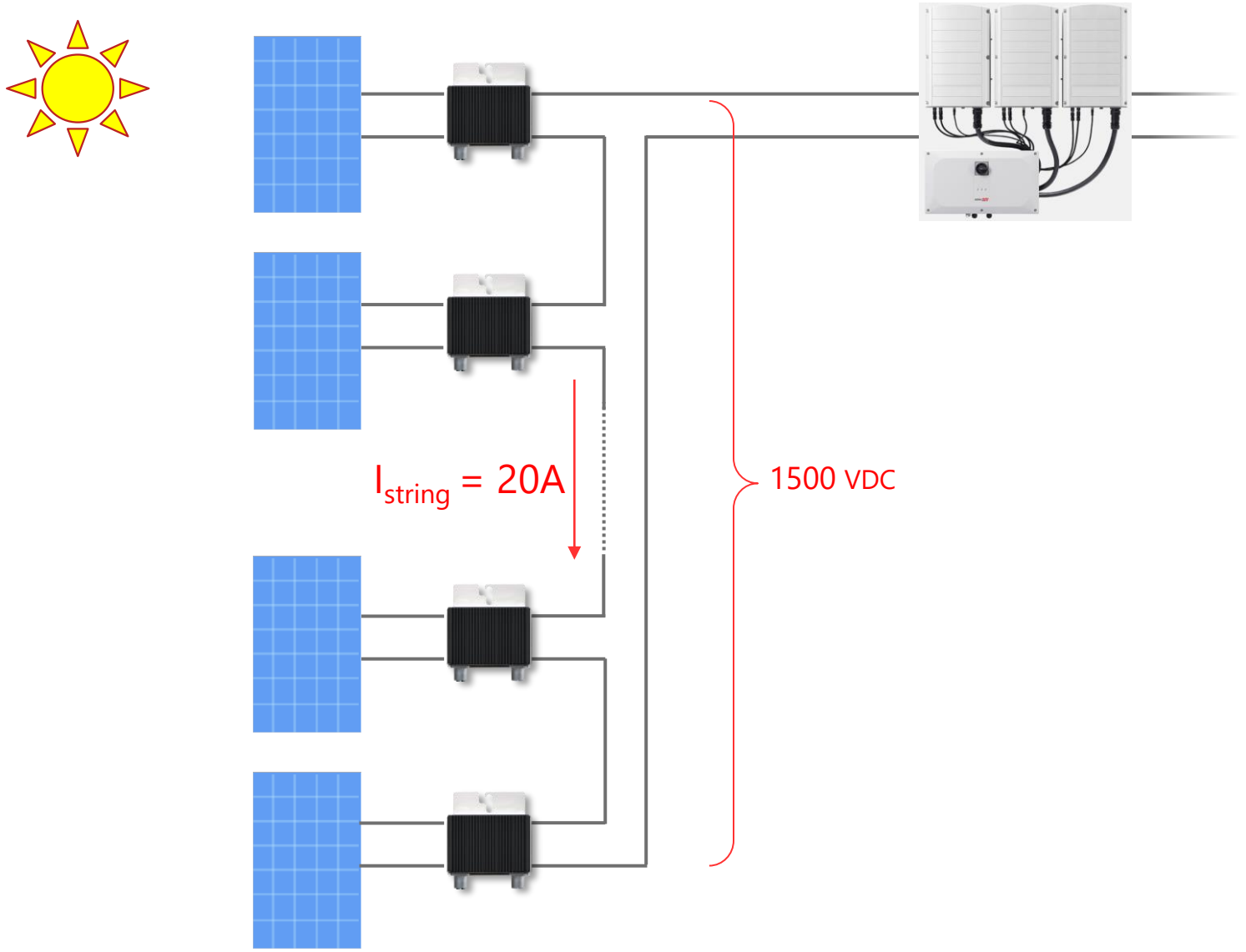
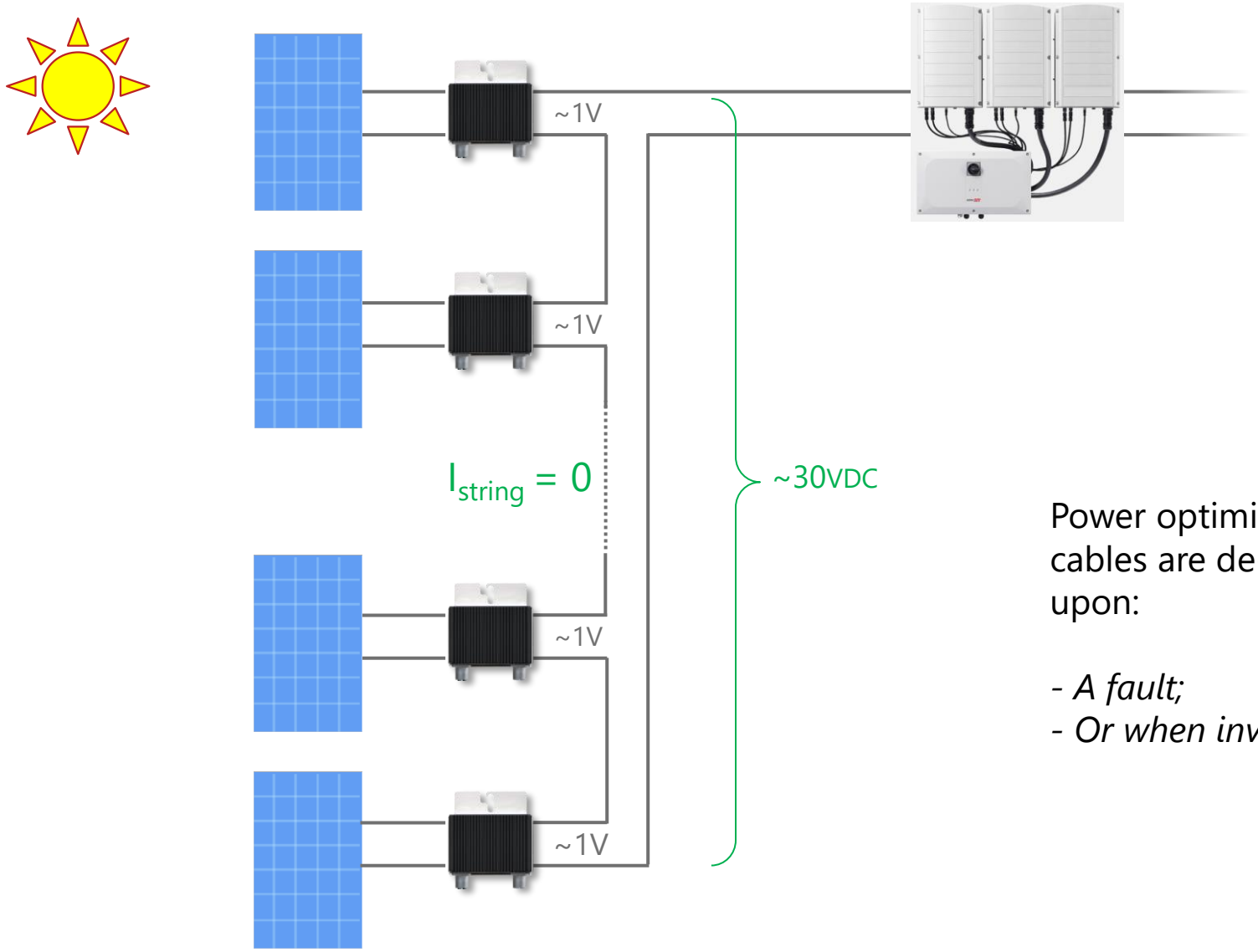
Systems with MLPE – SafeDC™

System ON



Systems with MLPE – SafeDC™

SafeDC™ Active



Power optimizers shut down and DC cables are de-energized automatically upon:

- *A fault;*
- *Or when inverter is off or disconnected*

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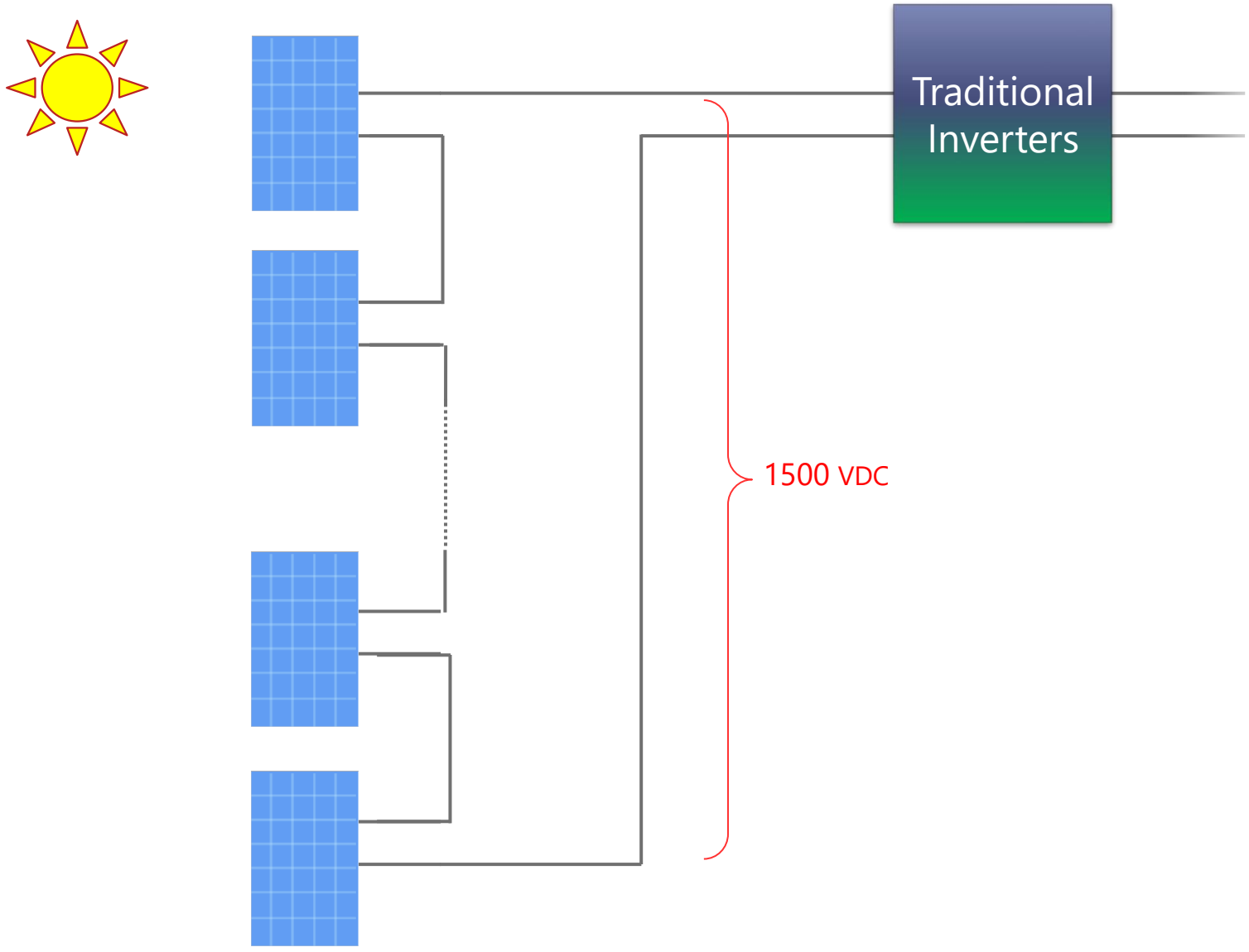
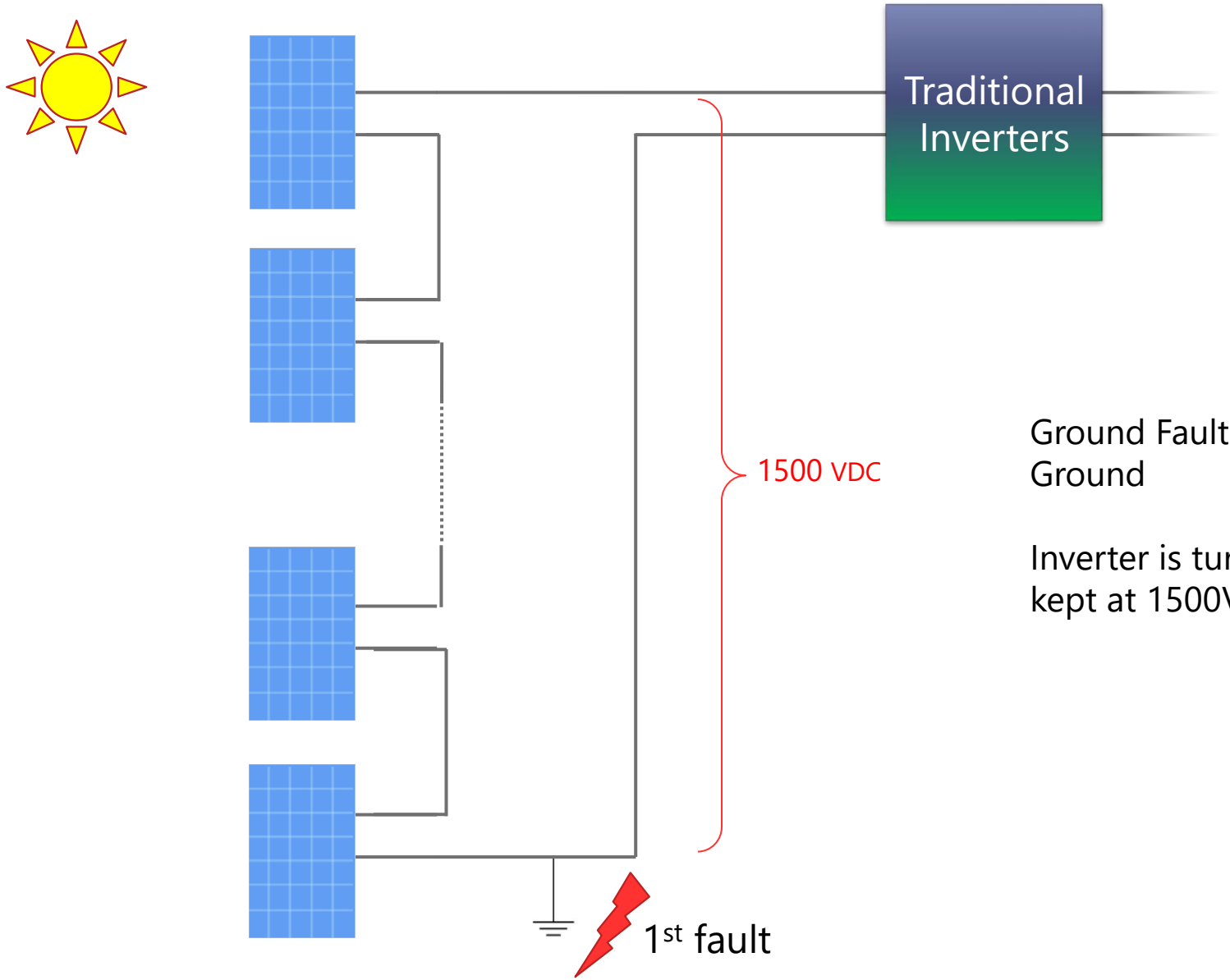
What happens upon a ground fault?

Systems do not react the same upon ground faults!

Traditional Systems – Ground Fault



Traditional Systems – Ground Fault



Ground Fault happens between Negative to Ground

Inverter is turned off, but array voltage is kept at 1500VDC during the day

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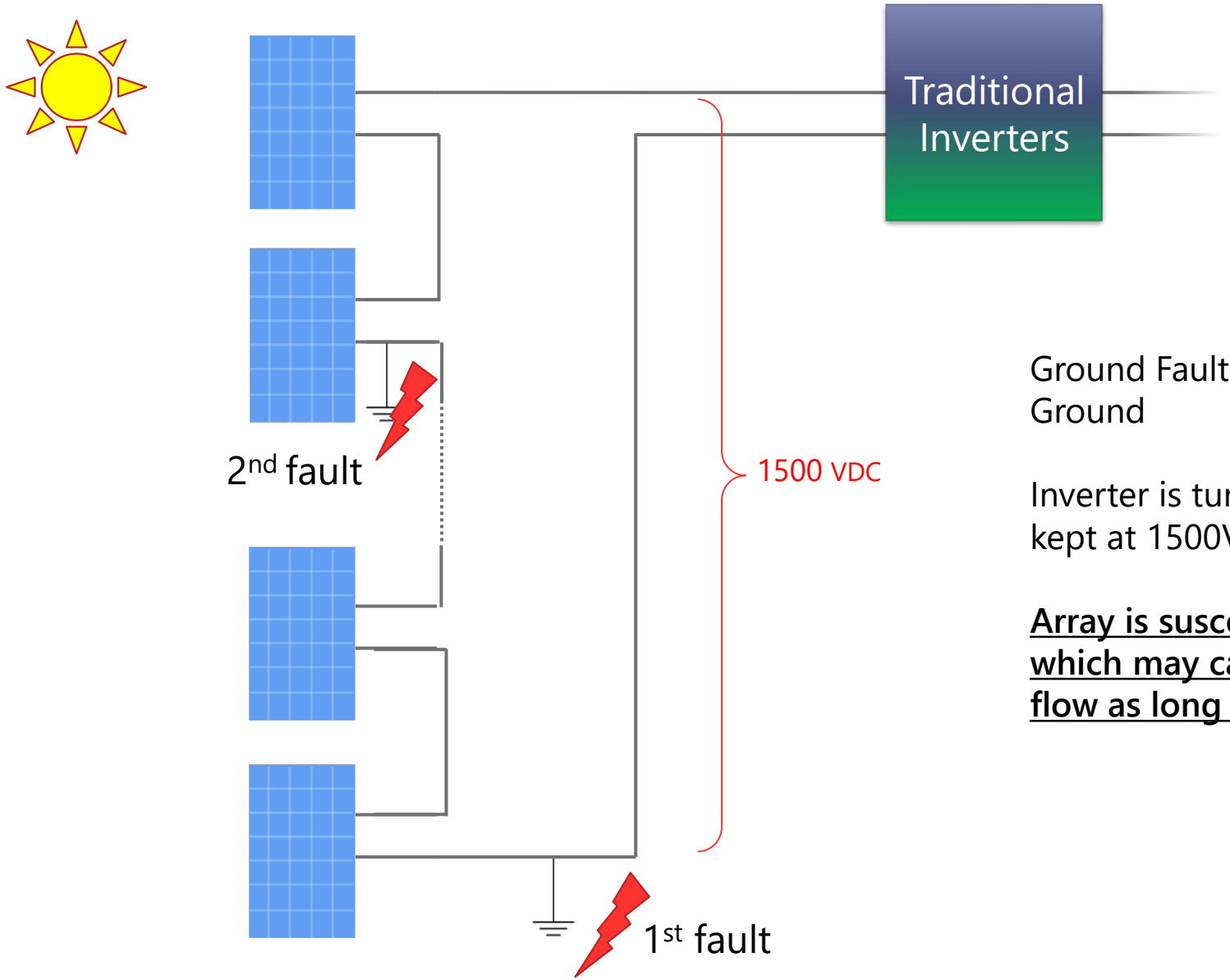
Traditional Systems – Ground Fault



Ground Fault happens between Negative to Ground

Inverter is turned off, but array voltage is kept at 1500VDC during the day

Array is susceptible to a 2nd ground fault which may cause unrestrained current to flow as long as the sun shines

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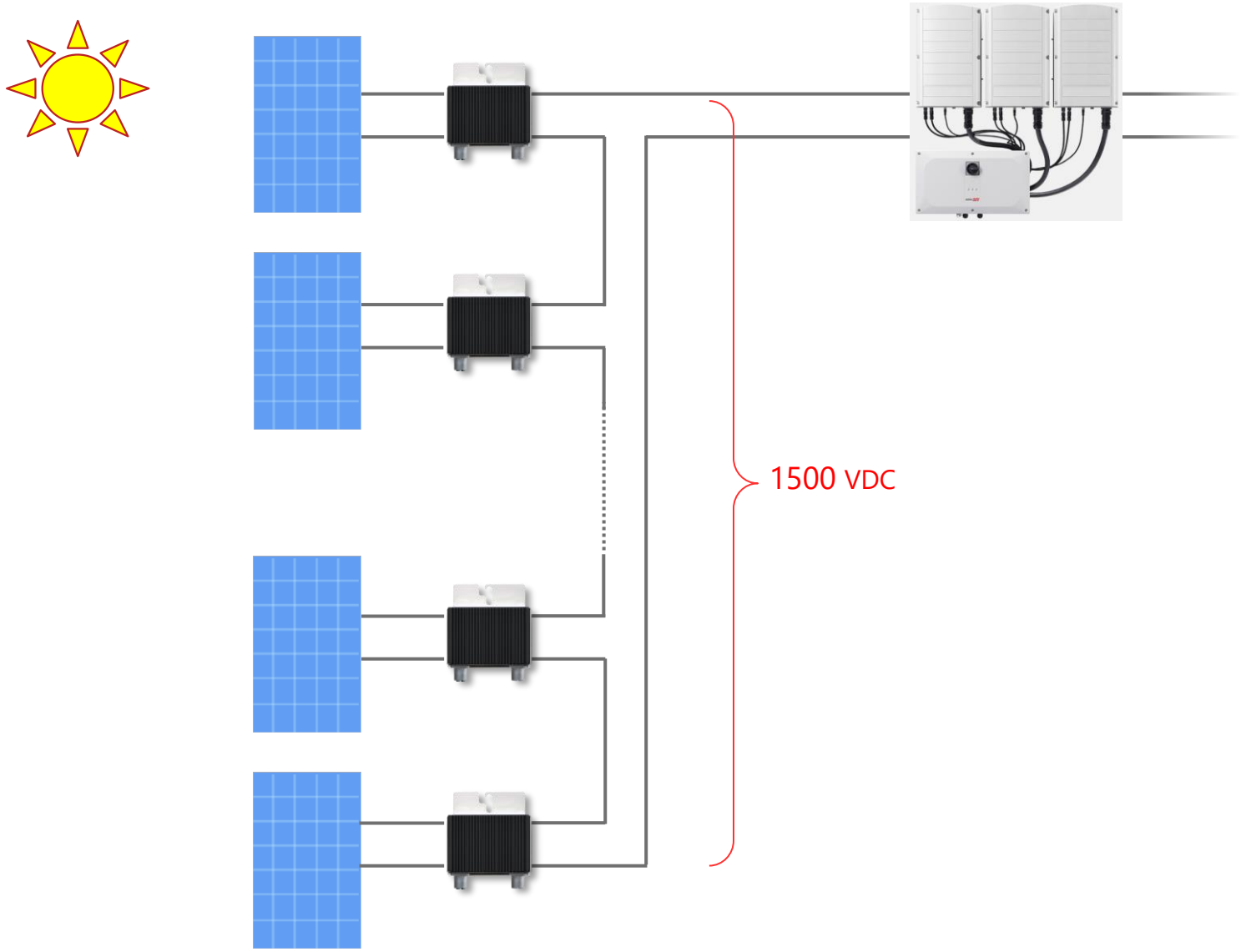
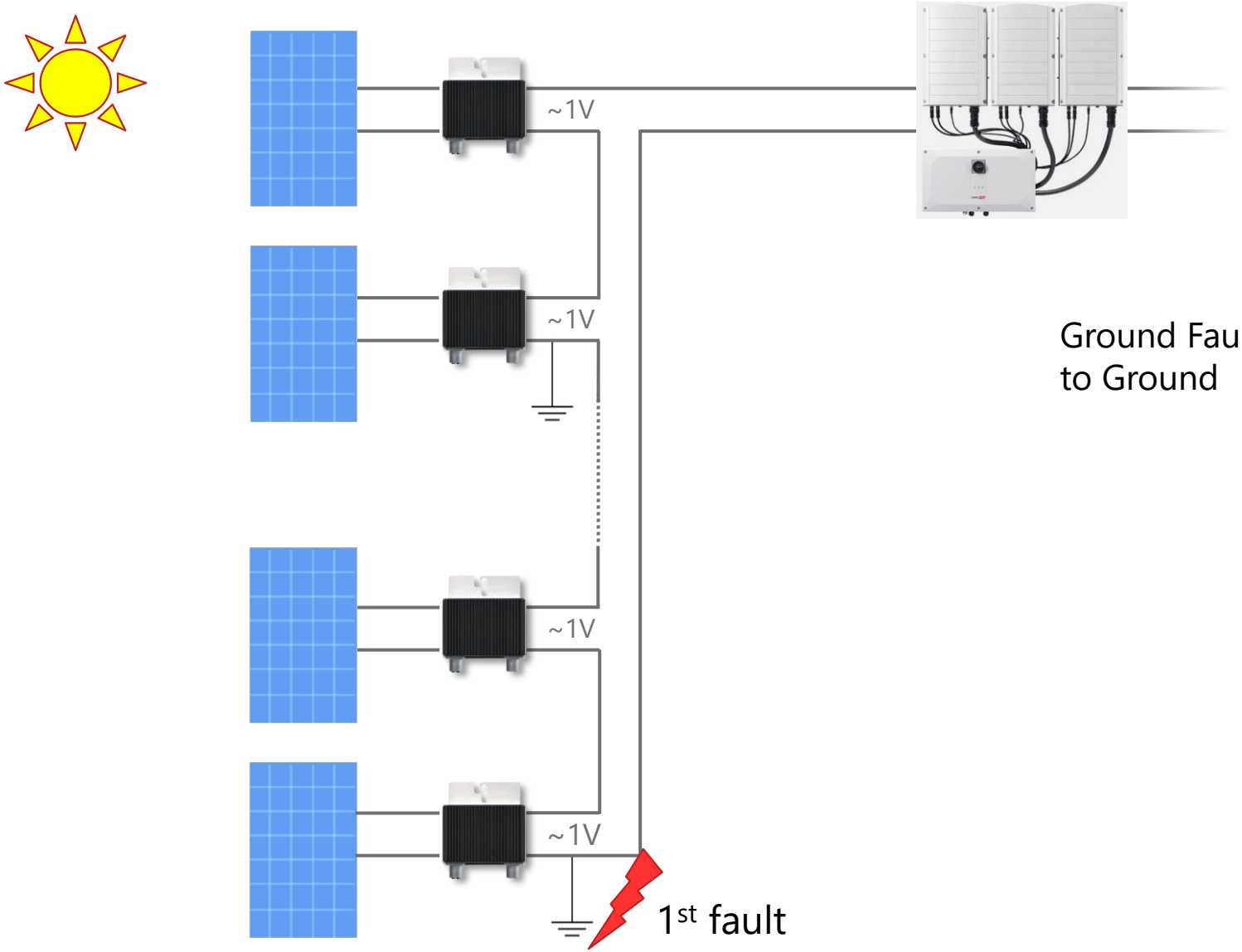
SolarEdge System – Ground Fault

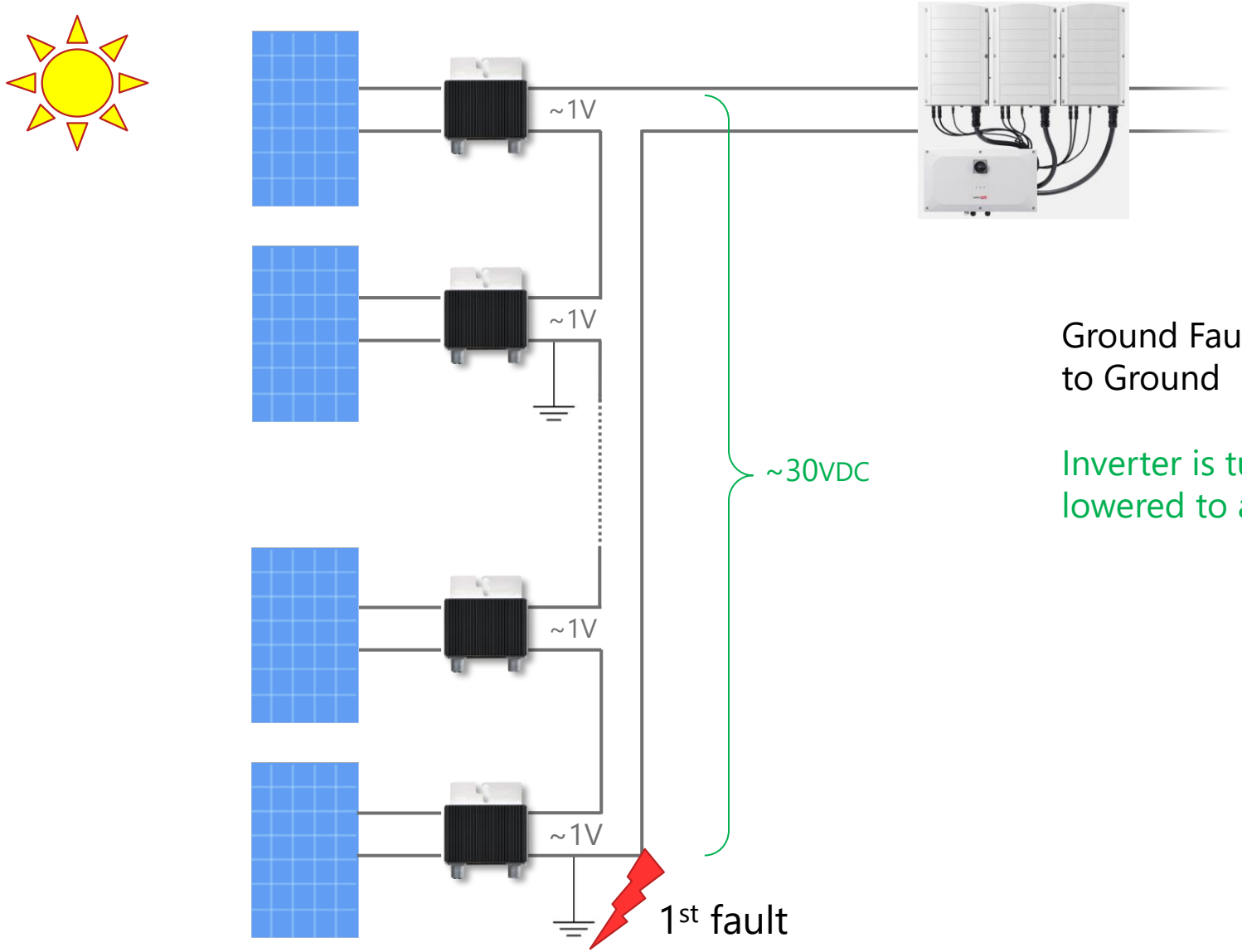


SolarEdge System – Ground Fault



Ground Fault happens between Negative to Ground

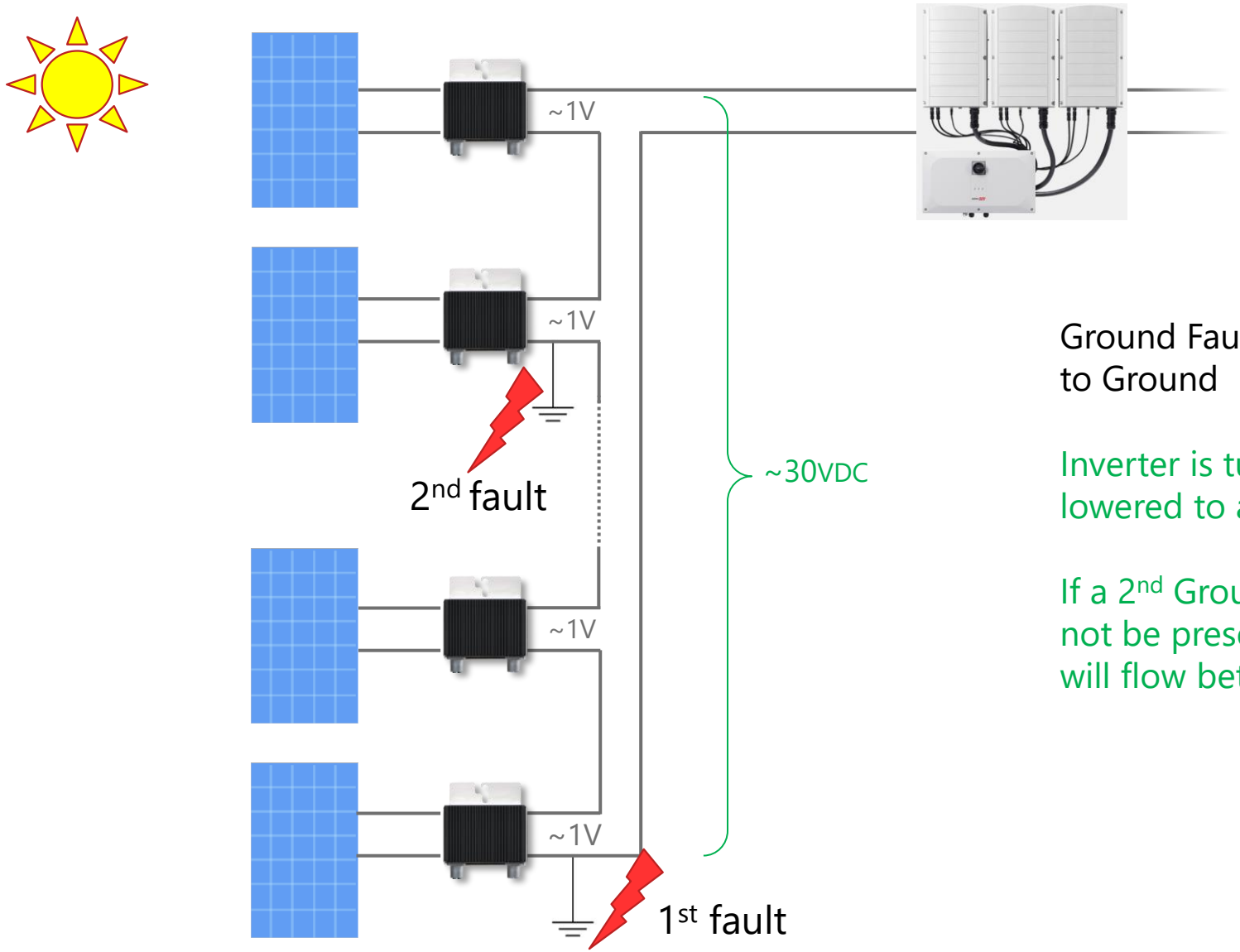
SolarEdge System – Ground Fault



Ground Fault happens between Negative to Ground

Inverter is turned off and array voltage is lowered to a safe voltage level

SolarEdge System – Ground Fault



Ground Fault happens between Negative to Ground

Inverter is turned off and array voltage is lowered to a safe voltage level

If a 2nd Ground Fault happens, voltage will not be present, and no undesired current will flow between the ground paths

PV Connector Issues – a hidden serious issue!

- PV Connector issues can lead to arc faults
- Issues are due to mismatch connectors, wear and tear and poor installation

"Catastrophic incidents that jeopardize safety and property are more likely to occur when faulty connectors continue operating in the field over time."

Source: PVEL and Heliovolta report: The Ultimate Safety Guide for Solar PV Connectors

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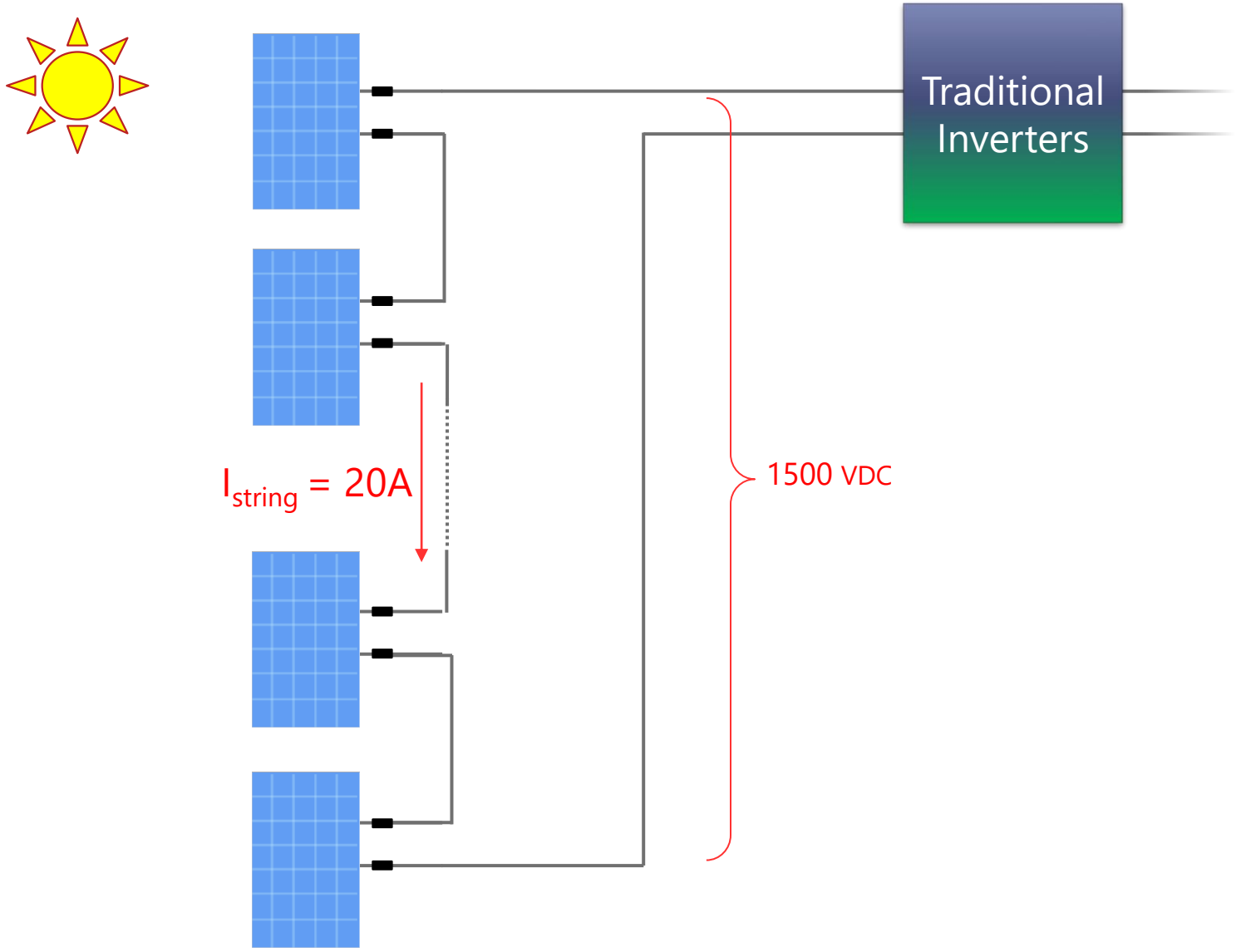
Traditional Systems – Potential Arc Faults



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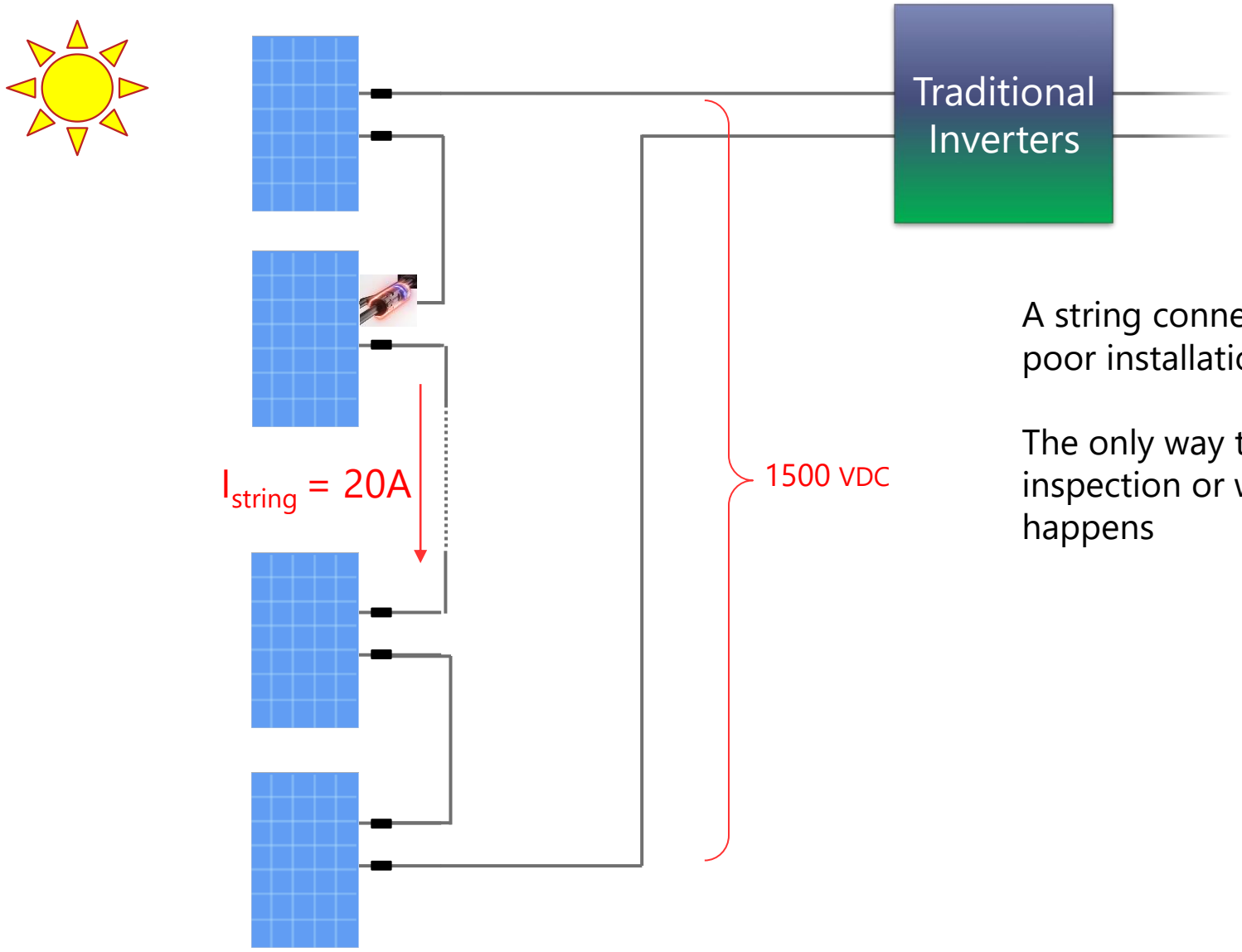
Traditional Systems – Potential Arc Faults



A string connector starts to overheat due to poor installation or wear and tear

The only way to detect is via ground thermal inspection or when a catastrophic failure happens

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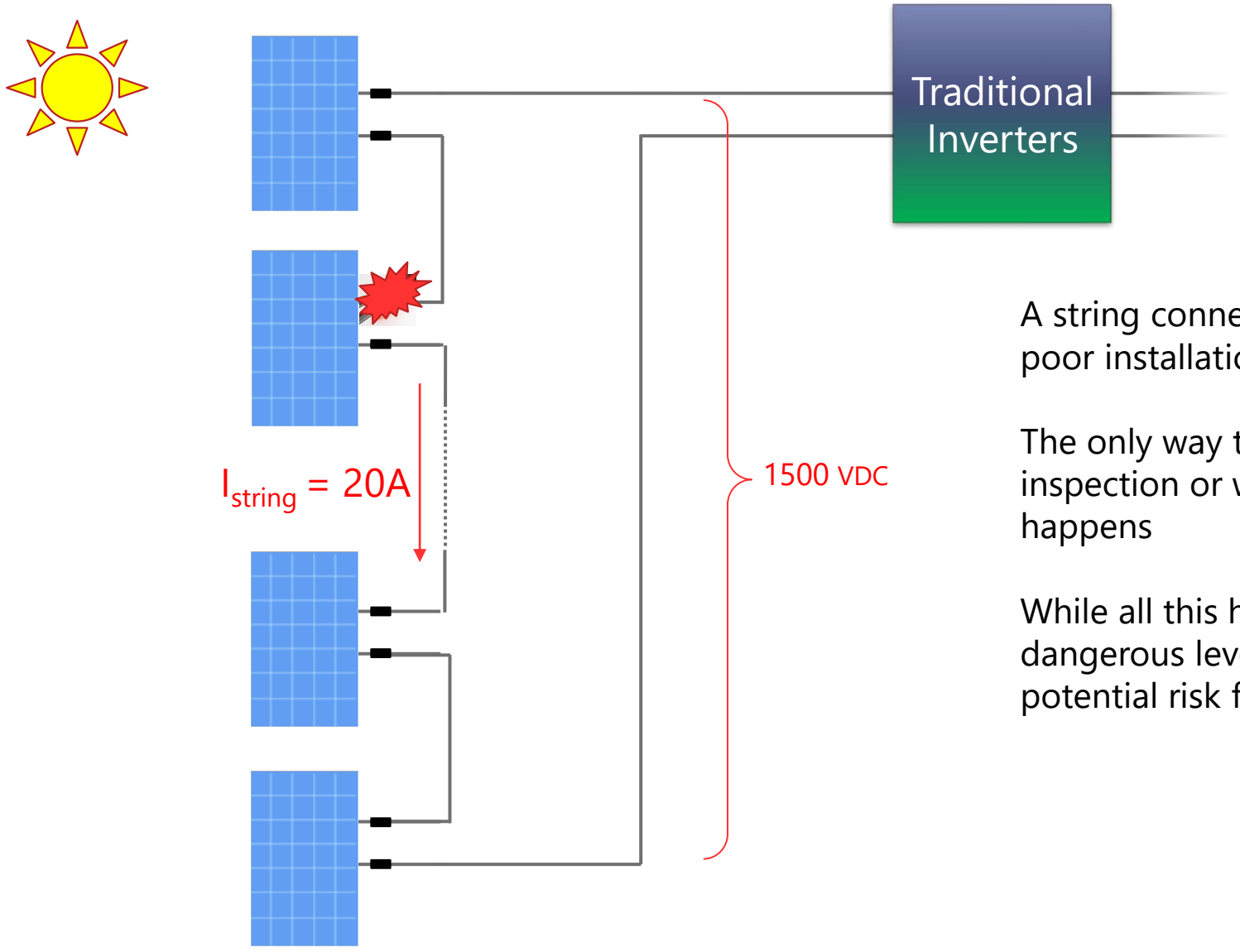
Traditional Systems – Potential Arc Faults



A string connector starts to overheat due to poor installation or wear and tear

The only way to detect is via ground thermal inspection or when a catastrophic failure happens

While all this happens, the array is kept at dangerous levels of 1500VDC introducing the potential risk for ground currents and fires

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Introducing the S-Series Power Optimizers

Safer with SolarEdge Sense Connect

A breakthrough in Power Optimizer safety providing **enhanced safety** for all

- Sense Connect technology constantly monitors Power Optimizers' connectors, identifying improper connections and possible malfunctions for early detection and mitigation of arc risks

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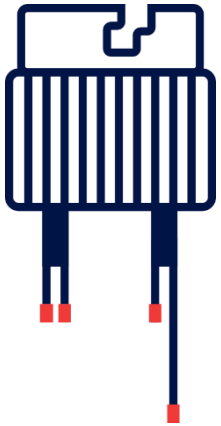
Maximizing System Safety with SolarEdge Sense Connect

Safe

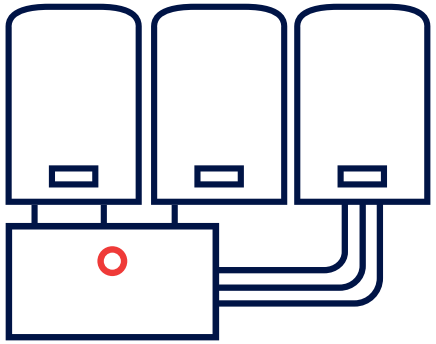
Early Detection

Early Detection of imminent arc threat



System is placed in Safe Mode

Inverter switches the system to a safe mode and voltage



Precise location and identification

Faulty connector location is visible in the Monitoring Platform

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A Smarter Power Optimizer

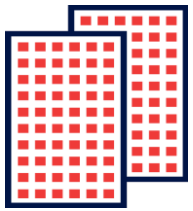
Smart

More design flexibility = More energy

- ✓ Supports high input current, bifacial & higher power modules, up to 2 x 600W in series
- ✓ 5-10% more energy production over system lifetime

Lower BoS and labor costs

- ✓ Up to 20A output per string
- ✓ Up to 50% less cables, fuses, combiner boxes, over 2X longer strings length possible



Pinpointed system monitoring

- ✓ Full performance visibility with remote module-level monitoring
- ✓ Automatic alerts on system issues

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S1200/1: Technical Specifications

Parameter	Value	Unit
Input		
Rated Input DC Power	1200	W
Absolute Maximum Input Voltage (Voc at lowest temperature)	125	Vdc
Maximum Short Circuit Current (Isc) of connected PV Module	15	Adc
Output During Operation		
Maximum Output Current	**20**	Adc
Maximum Output Voltage	80	Vdc
Efficiency		
Maximum Efficiency	99.5	%
Weighted Efficiency	98.8	%

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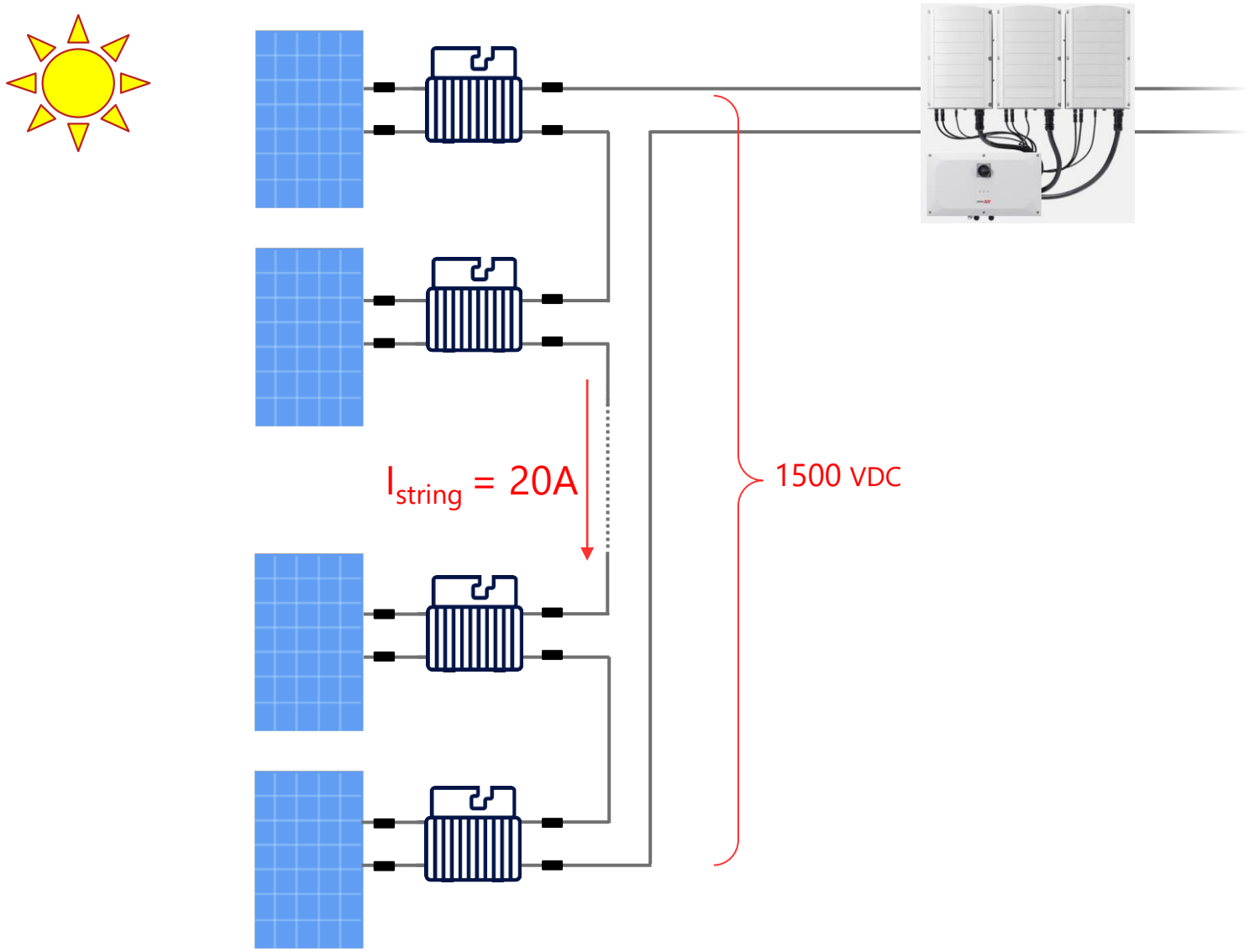
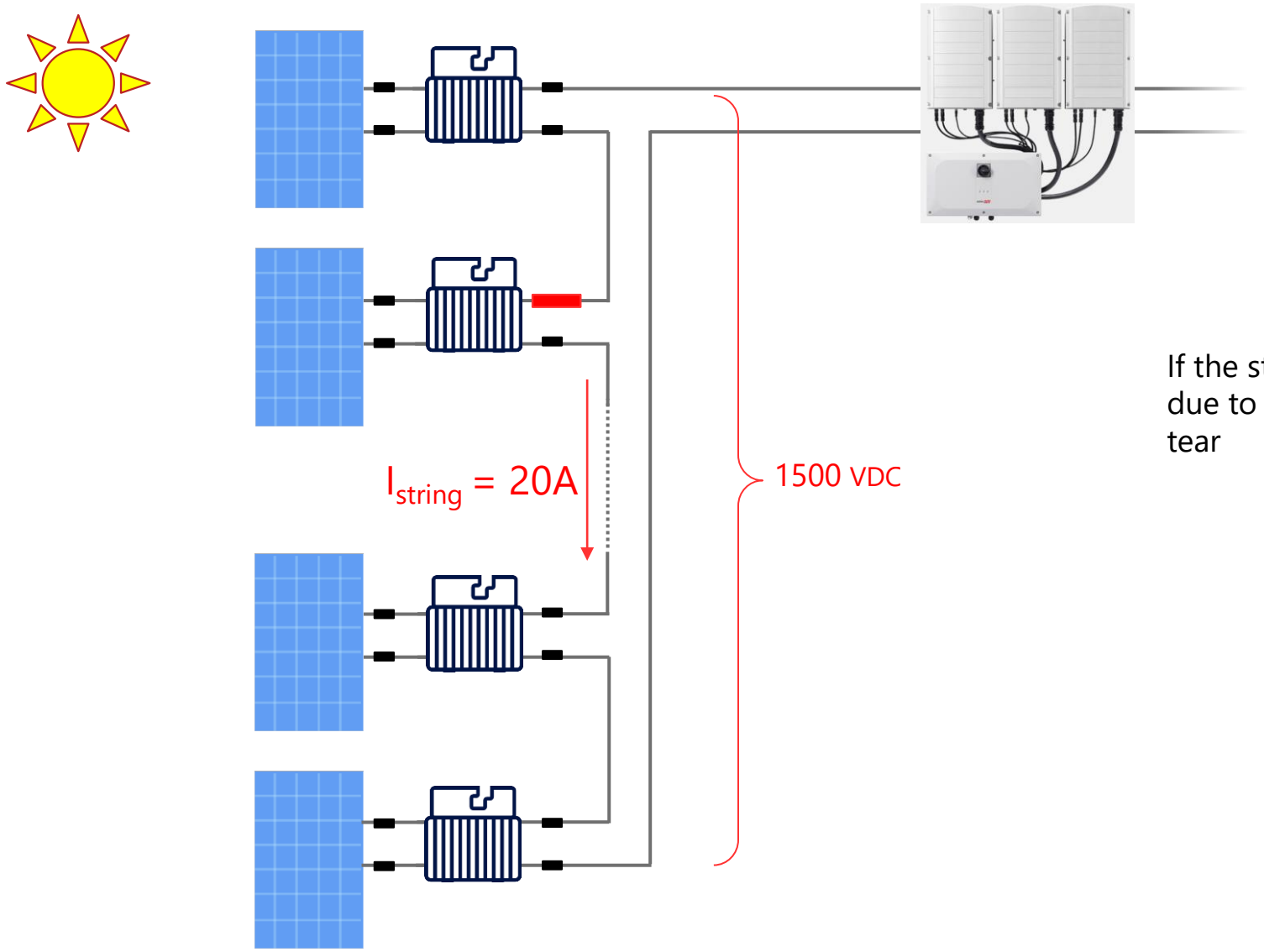
SolarEdge System – Normal Operation

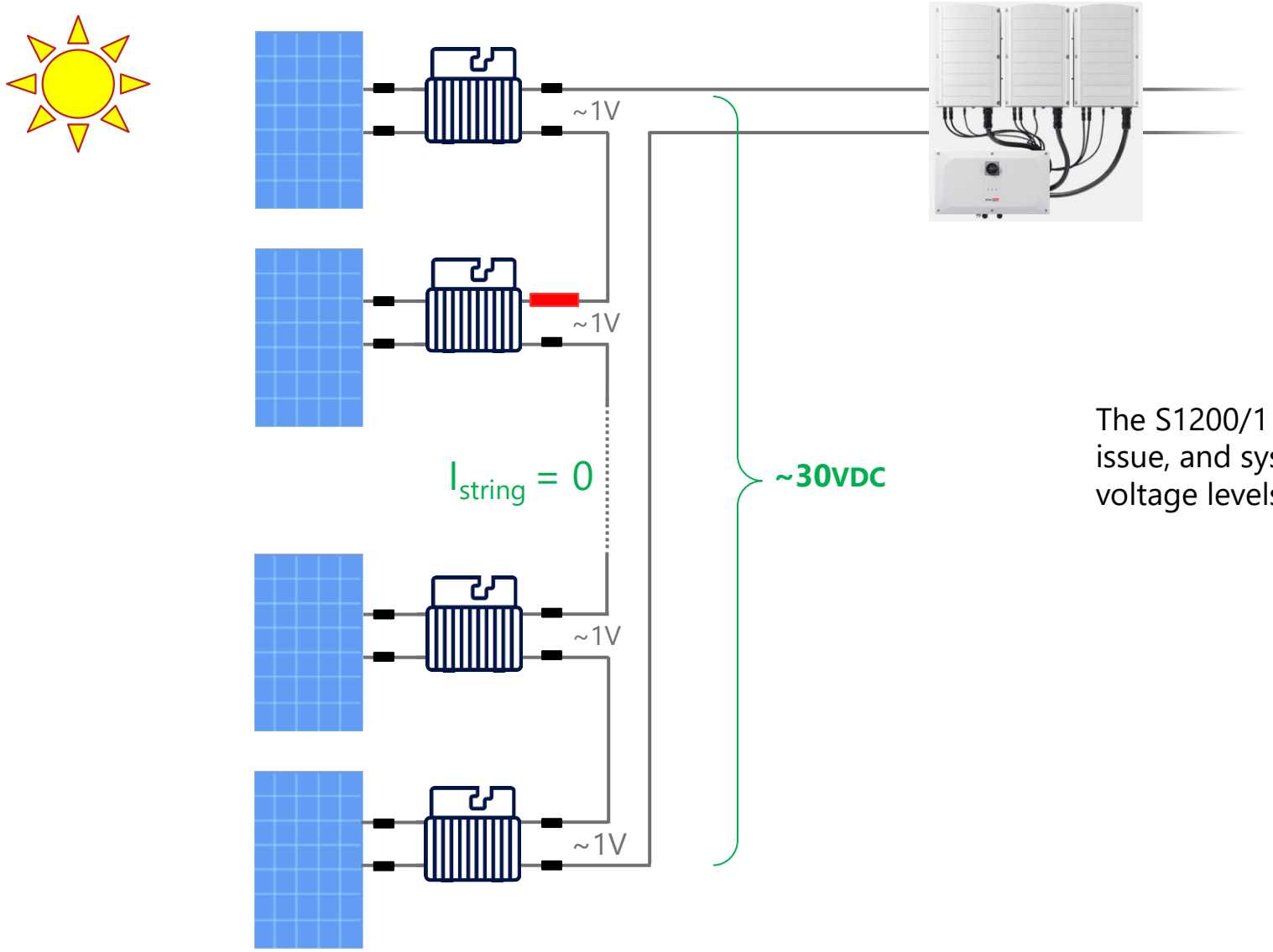


SolarEdge System – Normal Operation



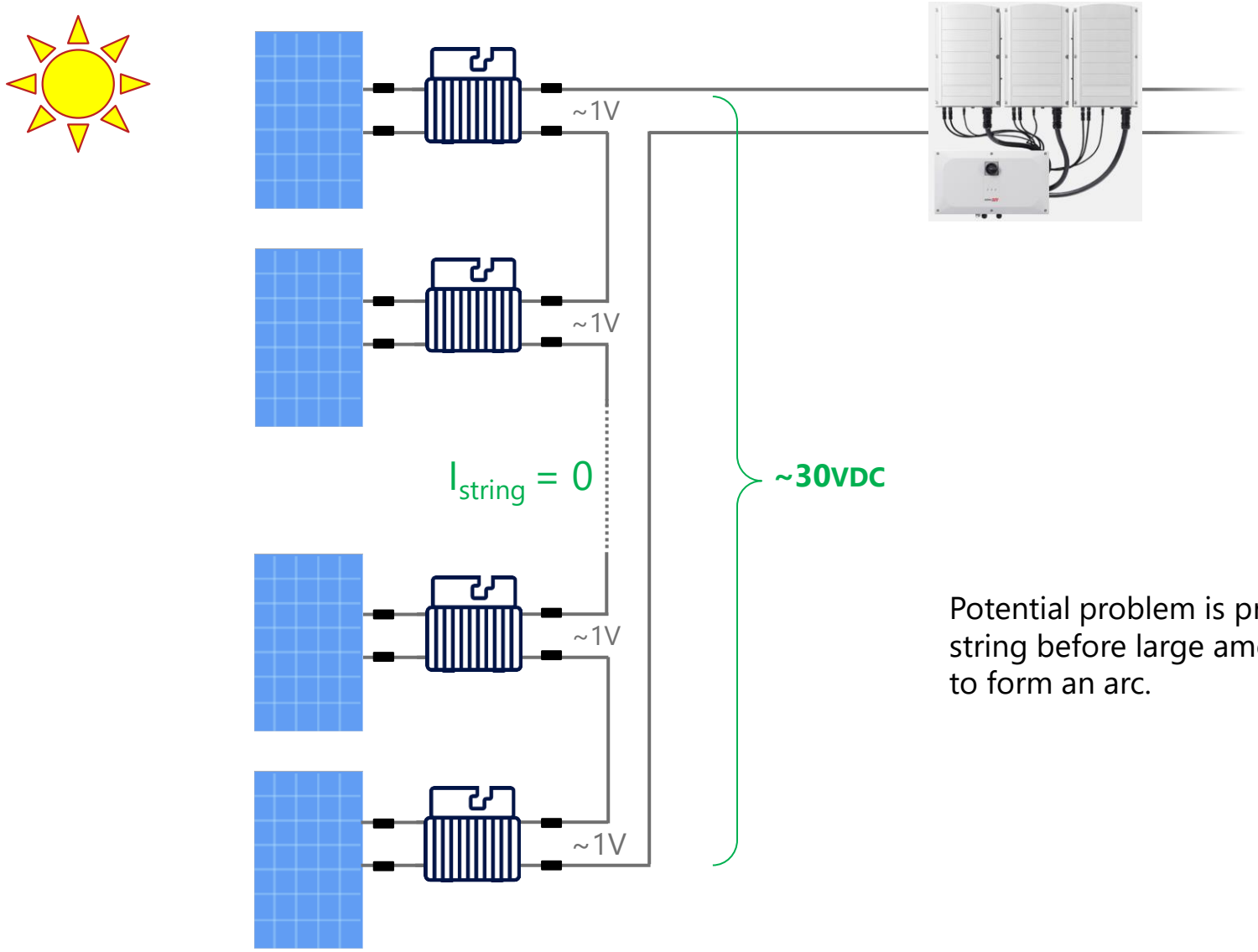
If the string connector starts to overheat due to connector mismatches or wear-tear

SolarEdge System – Early detection



The S1200/1 DC optimizer detects the potential issue, and system voltage is lowered to safe voltage levels and string current is stopped!

SolarEdge System – Early detection



Potential problem is prevented and isolated from the PV string before large amounts of energy are fed into the fault to form an arc.

Conclusion

Upon Ground Fault or System Maintenance

Desired Behavior	Conventional Systems	SolarEdge
De-energize array	✗	✓

Conclusion

PV connector temperature increase and suspicion of Arc Fault

Desired Behavior	Conventional Systems	SolarEdge
Early Detection	✗	✓
De-energize array	✗	✓
Stop the String Current Flow	✗	✓

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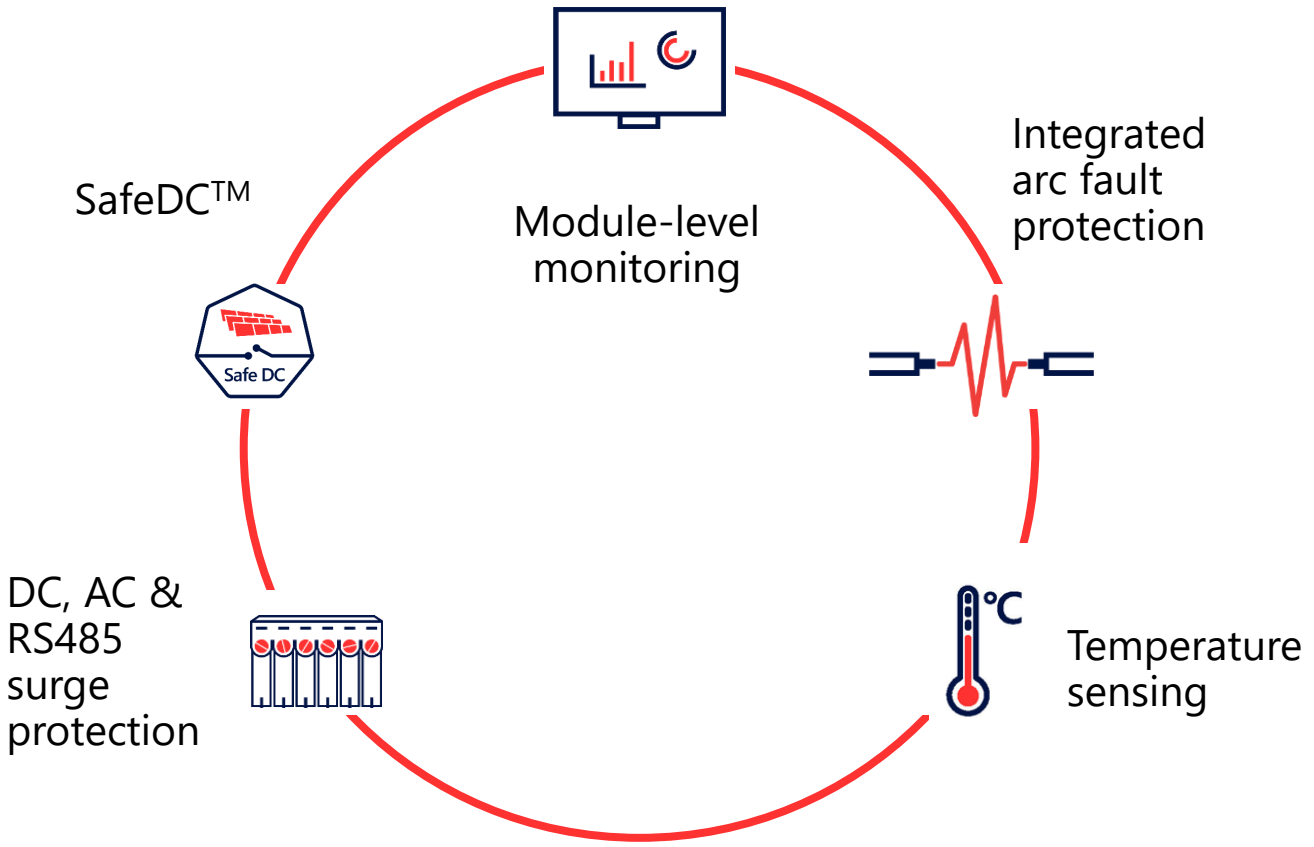
Leader in PV Safety

Safety starts at the module level with a holistic approach to PV safety

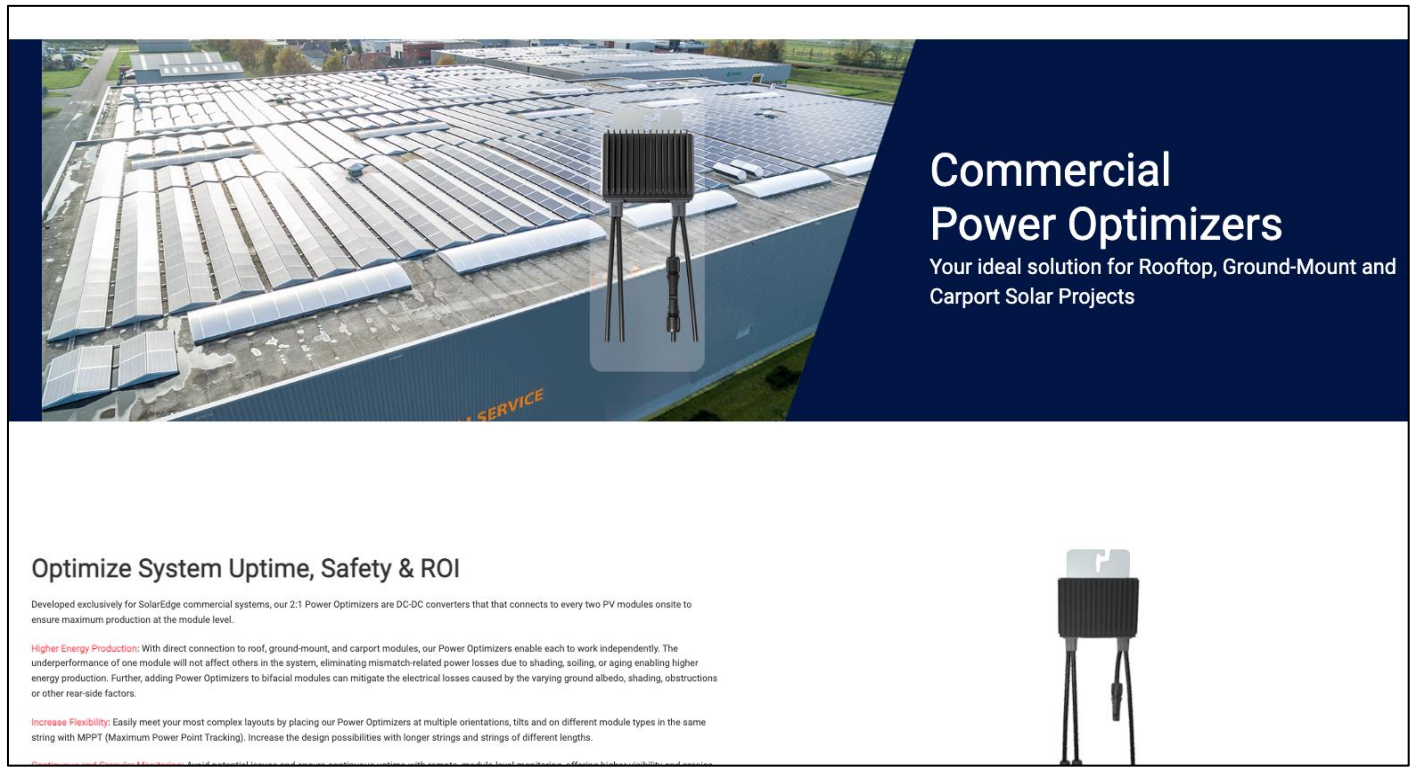
- Safe environment for installers, firefighters and maintenance personnel
- Holistic arc protection – prevention, detection and mitigation
- Reduce fire risks from external factors such as poor vegetation management



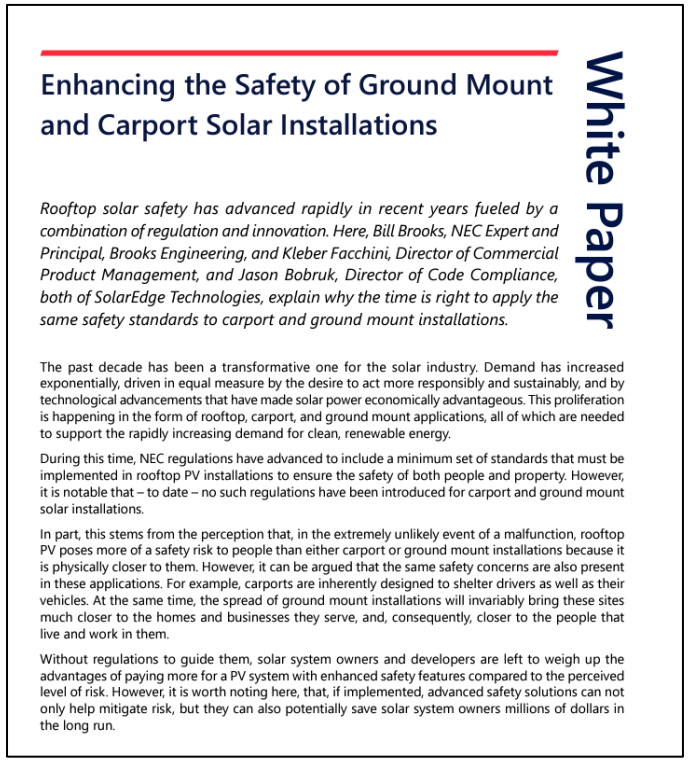
"We chose SolarEdge for their ability to meet NEC rapid shutdown codes, high quality, and exceptional safety record in the market. SolarEdge products maximize energy production while protecting our customers from the pitfalls of non-MLPE solutions." –Candice Michalowicz, Co-Founder and Managing Member, C2 Energy Capital

Meets leading property insurance company FM Global's DS 1-15 engineering requirements

Resources



S-Series Webpage



Safety Whitepaper

- Visit https://www.solaredge.com/us/solutions/commercial for more resources

Come visit us at RE+ next week!

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Q&A

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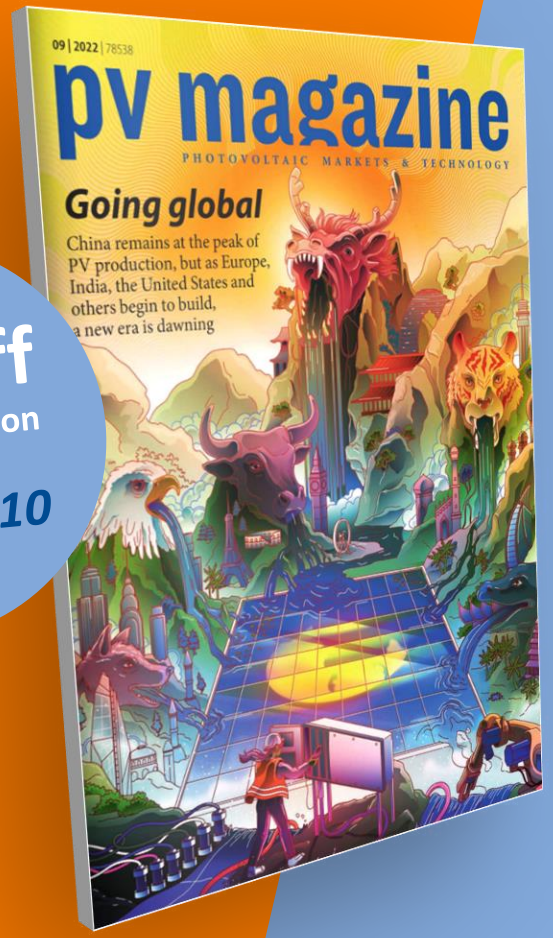
The latest news



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[Solar in the U.S. is forecast to triple in five years]
by Ryan Kennedy

[Shipments of module-level power electronics could hit 100 GW by 2026]
by Beatriz Santos

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Coming up next...

Wednesday, 21 September 2022
10:00 am - 11:00 am CEST, Madrid

Cómo ayudar a O&M, EPCs y propietarios de activos a convertir en éxito los riesgos del boom fotovoltaico

Thursday, 22 September 2022
10:00 – 11:00 México, Colombia, Perú
17:00 – 18:00 CEST, Madrid

Tecnología TOPCon de alta eficiencia para distintas latitudes en América Latina

Many more to come!

In the next weeks, we will continuously add further webinars & Spotlights with innovative partners and the latest topics. Check out our pv magazine program at:

www.pv-magazine.com/spotlights

Registration, downloads & recordings are also be found there.

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Thank you for joining us today!